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Species richness of bivalves and gastropods in Iwahig River-Estuary, Palawan, the Philippines

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Abstract
Iwahig River-Estuary in Palawan, Philippines is one of the least disturbed river-estuary systems where biodiversity remains undocumented. In this study, the molluscan fauna of Iwahig River-Estuary is based on samples taken from three site groups: mangrove forest, lower reaches of the river, and intertidal flat near the river mouth. We have listed a total of 15 bivalves and 50 gastropods species spread over among 25 families and 45 genera. Some of these species are habitat specific while others overlap across study sites. Among the recorded species *Nassarius pullus* and *Anadara uropigimelana* had the widest range of distribution occurring in mangrove forest, river bed, and intertidal flats thereby considered as a potential biological indicator for climate change adaptation and mitigation studies. Commercially exploited species for food and local shell craft industry include nine bivalves and two gastropods. Some other species have the potentials for aquaculture and shell trade. Exploring the potentials of these species as source of sustainable income for the locals is suggested.

Keywords: bivalves, Iwahig River, gastropods, mangrove estuary, Palawan.

1. Introduction
Mangrove forest is one of the most important ecosystems in the world because of its significant role in the environment and fisheries. Molluscs of commercial importance comprise the biodiversity and secondary productivity of mangrove forest. Studies on molluscan species richness in Palawan are fragmented while studies dealing more specifically with mangrove associated molluscs in the province seem non-existent. To date, molluscan diversity studies in Palawan are limited to the northern parts of the province where 716 species have so far been recorded [1] and more than 200 species have been recorded in Tubbataha Reefs Natural Park [2]. Iwahig River-Estuary being under the jurisdiction of Iwahig Penal Farm is among the least disturbed river-estuary systems in Palawan compared to other rivers proximate to the City of Puerto Princesa. Fireflies inhabit some mangrove trees along the river bank making it one of the city's most popular tourist destinations. The mollusc resources in the area are harvested and locally sold by artisanal fishermen. With the gradual increase in the number of residents at the lower reaches of the river, species diversity may be affected with unregulated harvesting and mangrove cutting activities [3, 4]. This paper aims to provide species inventory of molluscan (bivalves and gastropods) species in Iwahig River-Estuary in its least disturbed state.

2. Methods
The study was conducted in Iwahig River–Estuary (9°44'10.96"N and 118°41'50.69"E), Puerto Princesa City, Palawan, Philippines. Sampling of bivalves and gastropods was conducted from April 2013 – February 2014. Samples were collected at several sites within the mangrove forest. Specimens at the lower reaches of the river were obtained by one time dredging in March 2014. Collection of samples in the intertidal area was conducted by gleaning during low tide and by dredging at high tide.
For the commercially harvested molluscs, sampling was conducted in two vending stalls in Bucana Village (9°44'27.80"N, 118°41'2.01"E) located adjacent to Iwahig River (Figure 1). Species identification was based on the works of Springsteen and Leobrera [5], Hardy [6], Abbott and Dance [7] and Laureta [8]. Photos of tentatively identified species were sent to experts for confirmation.

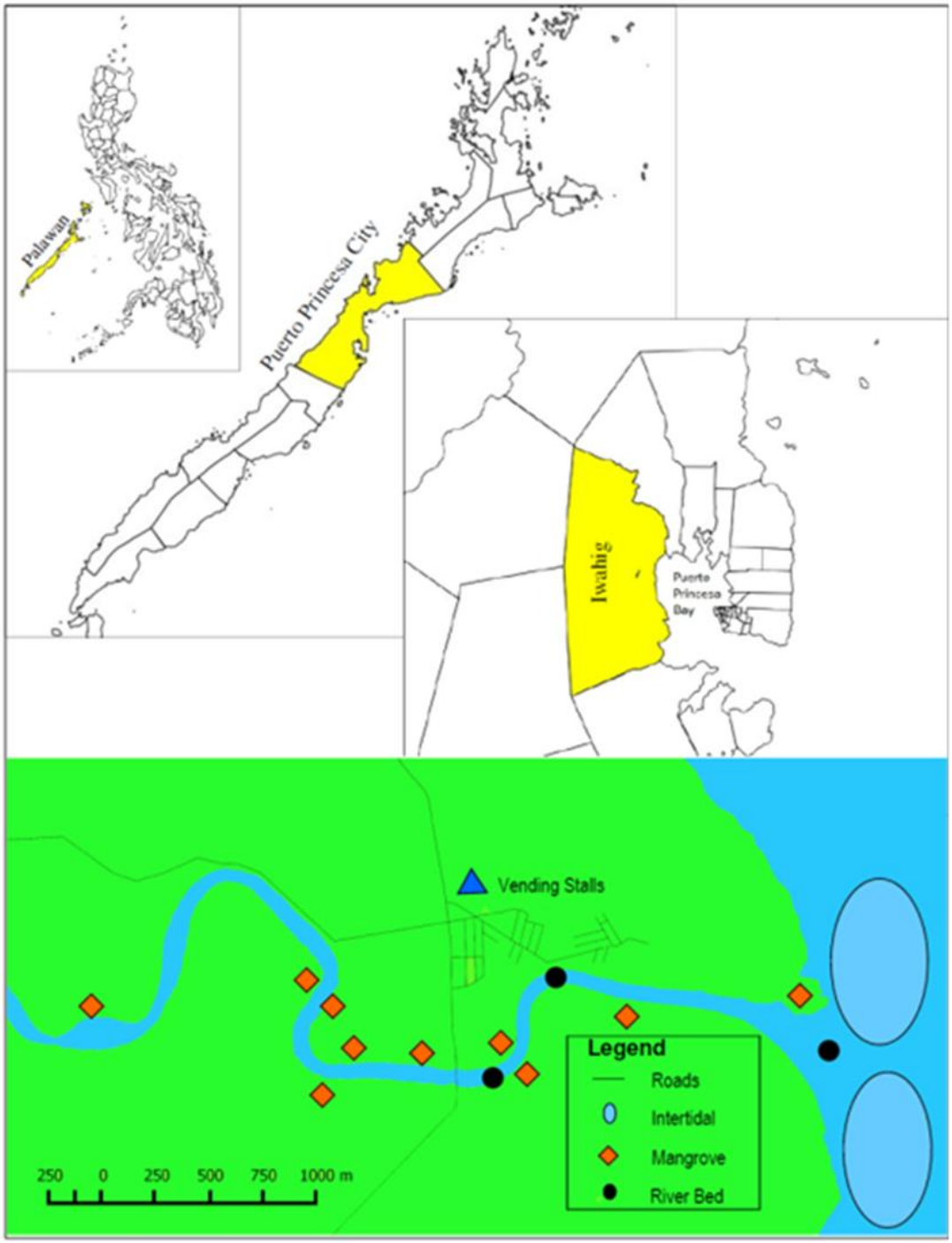

Fig 1: The sampling sites in Iwahig River, Palawan, Philippines. Insets are the maps of the Philippines, Palawan, and Iwahig River.

3. Results

A total of 65 species of shelled molluscs belonging to 25 families and 45 genera were recorded at the study sites. The number (23%) of bivalve species is much lower than gastropods (77%) (Table 1). The 15 species of bivalves belonged to six families and 14 genera. While the 50 gastropod species fall under 19 families and 31 genera.

In general, the number of species in the three habitats (mangrove, river bed and intertidal area) ranged between 23-24 species. As for bivalves, the highest number of species was recorded at the vending stalls (10 or 67%) and only four (27%) species were noted in the mangrove forest (Table 1, Figure 2). Of the 10 species being sold in stalls, four species were either river or intertidal in origin, two mangrove associates, and two solely intertidal. Two out of four mangrove associated bivalves, the *Polymesoda erosa* and *Anadara uropigimelana* were highly exploited for food. *Cyclina orientalis*, *Azorinus coarctatus* and *Anadara granosa* were found in vending stalls, but not in study sites. *Anadara granosa* may have been collected from nearby muddy habitats where it is more abundant while *C. orientalis* and *A. coarctatus* may prefer fine sandy area in the sea grass beds. Most bivalves obtained by dredging (lower reaches of the river) were very small (about 10 mm) and could be immature individuals.

Of the 50 species of gastropods, 26 (52%) species were encountered in the intertidal area, 20 (40%) at the mangrove forest and 17 (34%) from the river bed (Table 1, Figures 3-5). Among these, three species occurred both at the mangrove forest and river bed; 10 species occurred both

at the river bed and the intertidal area; while two species, the *Nassarius pullus* and *A. uropigimelana* occurred in all three habitats. Only two species were displayed for sale at vending stalls.

Fig 2: Species of bivalves encountered in Iwahig River-Estuary, Palawan, Philippines. 1) *Placuna placenta*, 2) *Enigmonia aenigmatica*, 3) *Anadara uropigimelana*, 4) *Anadara granosa*, 5) *Potiarca pilula*, 6) *Polymesoda erosa*, 7) *Isognomon ephippium*, 8) *Azorinus coarctatus*, 9) *Anomalocardia squamosa*, 10) *Callista erycina*, 11) *Clausinella chlorotica*, 12) *Gafrarium pectinatum*, 13) *Meretrix meretrix*, 14) *Paphia undulata*, 15) *Cyclina orientalis.*

Fig 3: Some species of gastropods encountered in Iwahig River-Estuary, Palawan, Philippines. 16) *Architechtonica perspectiva*, 17) *Assiminea brevicula brevicula*, 18) *Cerithium coralium,* 19) *Eucithara stromboides*, 20) *Eucithara marginelloides*, 21) *Euplica scripta*, 22) *Vexillum amandum*, 23) *Vexillum funereum*, 24) *Vexillum rugosum*, 25) *Vexillum virgo,* 26) *Vexillum vulpecula*, 27) *Ellobium aurisjudae*, 28) *Epitonium sandwichensis*

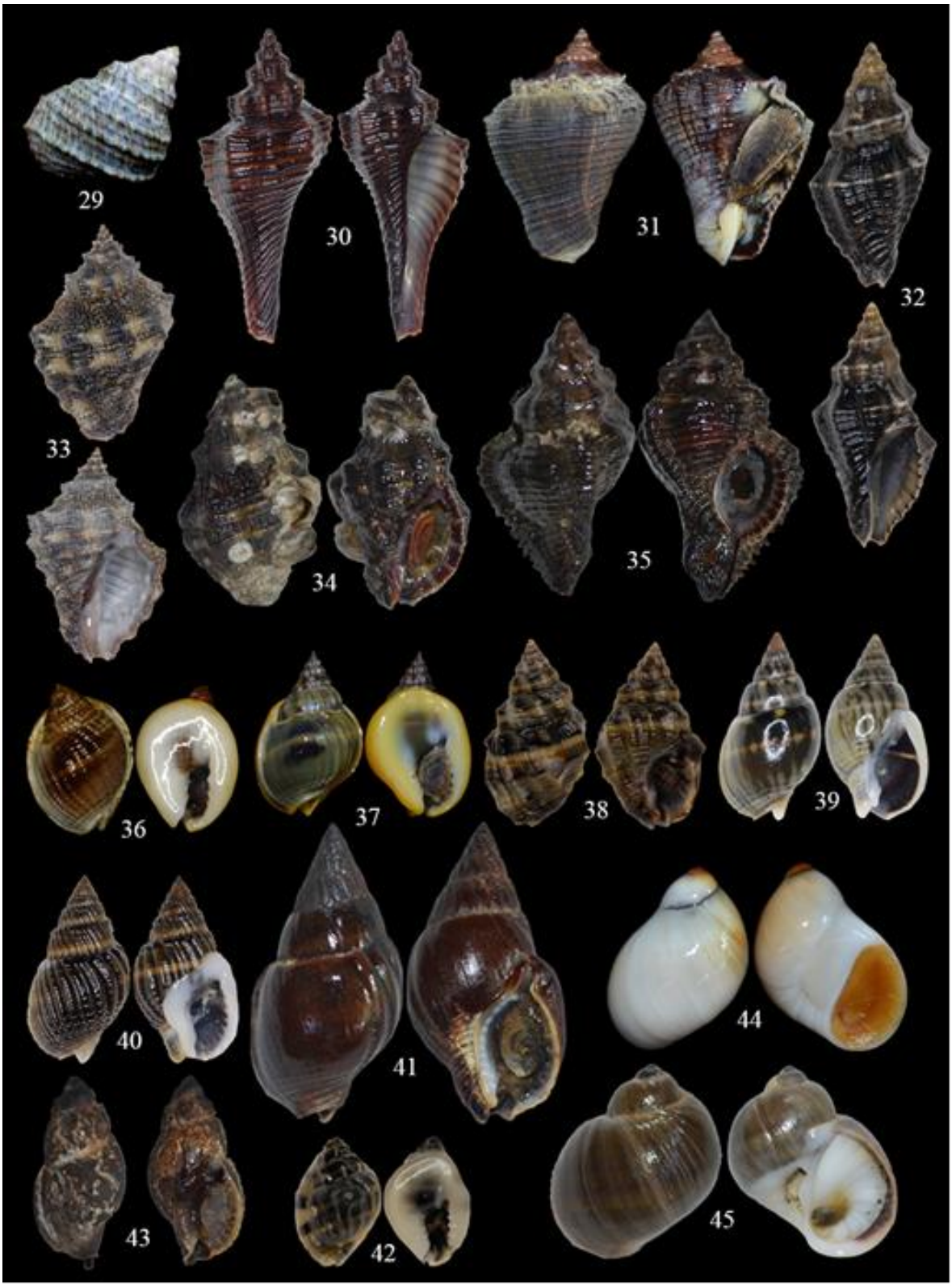

Fig 4: Some species of gastropods encountered in Iwahig River-Estuary, Palawan, Philippines. 29) *Littoraria carinifera*, 30) *Hemifusus ternatanus*, 31) *Volema myristica*, 32) *Drupella margariticola*, 33) *Semiricinula turbinoides*, 34) *Semiricinula muricina*, 35) *Chicoreus capucinus*, 36) *Nassarius globosus*, 37) *Nassarius pullus*, 38) *Hebra corticata*, 39) *Nassarius reeveanus*, 40) *Nassarius livescens*, 41) *Nassarius olivaceus*, 42) *Nassarius camelus*, 43) *Nassarius melanioides*, 44) *Polinices flemingianus*, 45) *Notocochlis (Nautica) qualteriana.*

Fig 5: Some species of gastropods encountered in Iwahig River-Estuary, Palawan, Philippines. 46) *Nerita exuvia*, 47) *Nerita violacea*, 48) *Neritina coromandeliana*, 49) *Telescopium telescopium*, 50) *Terebralia palustris*, 51) *Cerithideopsilla microptera*, 52) *Cerithidea quadrata*, 53) *Terebralia sulcata*, 54) *Otopleura auriscati*, 55) *Pyramidella dolabrata dolabrata*, 56) *Syrnola adamsi*, 57) *Syrnola jaculum*, 58) *Canarium urceus*, 59) *Laevistrombus turturella*, 60) *Hastula matheroniana*, 61) *Terebra anilis*, 62) *Terebra plumbeum*, 63) *Terebra succincta*, 64) *Terebra swainsoni*, 65) *Umbonium elegans.*

Table 1: Species of bivalves and gastropods encountered in Iwahig River and its vicinity.

BIVALVIA							
Family	**Species**	**English Name**	**Mangrove**	**River Bed**	**Intertidal**	**Sold in Stalls**	**Number**
Anomiidae	*Placuna placenta* (Linnaeus, 1758)	Window-pane Oyster			+	+	1
	Enigmonia aenigmatica (Holten, 1803)	Mangrove Jingle Shell	+				2
Arcidae	*Anadara uropigimelana* (Bory St. Vincent, 1824)		+	+	+	+	3
	Anadara granosa (Linnaeus, 1758)	Granular Ark				+	4
	Potiarca pilula (Reeve, 1843)	Ark Shell			+		5
Corbiculidae	*Polymesoda erosa* (Solander, 1786)	Mangrove Clam	+			+	6
Isognomonidae	*Isognomon ephippium* (Linnaeus , 1758)	Saddle Tree Oyster	+				7
Solecurtidae	*Azorinus coarctatus* (Gmelin, 1791)					+	8
Veneridae	*Anomalocardia squamosa* (Linnaeus , 1758)	Squamose Venus		+	+	+	9
	Callista erycina (Linnaeus, 1758)	Reddish Venus		+	+	+	10
	Clausinella chlorotica (Philippi, 1849)	Flowery Venus		+	+		11
	Grafarium pectinatum (Linnaeus, 1758)	Tumid Venus			+	+	12
	Meretrix meretrix (Linnaeus , 1758)	Meretrix Venus		+	+	+	13
	Paphia undulata (Born, 1778)	Undulating Venus		+			14
	Cyclina orientalis (Sowerby II, 1852)					+	15
Sub Total	15		4	6	8	10	
Percentage			27	40	53	66	
GASTROPODA							
Family	**Species**	**English Name**	**Mangrove**	**River Bed**	**Intertidal**	**Sold in Stalls**	**Number**
Architectonidae	*Architectonica perspectiva* (Linnaeus, 1758)	Clear Sundial		+			16
Assimineidae	*Assiminea brevicula* (Pfeiffer, 1854)	Red Berry Snail	+				17
Cerithidae	*Cerithium coralium* (Kiener, 1841)			+	+		18
Clathurellidae	*Eucithara stromboides* (Reeve, 1846)			+	+		19
	Eucithara marginelloides (Reeve, 1846)				+		20
Columbellidae	*Euplica scripta* (Lamarck, 1822)	Dotted Dove Shell			+		21
Costellariidae	*Vexillum amandum* (Reeve, 1845)	Amanda Mitre		+	+		22
	Vexillum funereum (Reeve, 1844)				+		23
	Vexillum rugosum (Gmelin, 1791)	Rugose Mitre			+		24
	Vexillum virgo (Linnaeus, 1767)	Blood-stained			+		25
	Vexillum vulpecula (Linnaeus, 1758)	Little Fox Miter			+		26
Ellobiidae	*Ellobium aurisjudae* (Linnaeus, 1758)		+				27
Epitoniidae	*Epitonium sandwichensis* (Pease, 1868)						28
Littorinidae	*Littoraria carnifera (*Menke, 1830)		+				29
Melongenidae	*Hemifusus ternatanus* (Gmelin, 1791)	Ternate False Fusus		+			30
	Volema myristica (Röding, 1798)	Nutmeg Melongena	+		+		31
Muricidae	*Drupella margariticola* (Broderip, 1833)		+	+			32
	Semiricinula turbinoides (Blainville, 1832)			+			33
	Semiricinula muricina (Blainville, 1832)	Marginate Drupe	+				34
	Chicoreus capucinus (Lamarck, 1852)	Quadrate Murex	+				35
Nassariidae	*Nassarius globosus* Quoy & Gaimard, 1833	Globose Nassa		+	+		36
	Nassarius pullus (Linnaeus, 1758)	Black Nassa	+	+	+		37
	Hebra corticata (Adams, 1852)			+	+		38
	Nassarius reeveanus (Dunker, 1847)	Gaudy Nassa		+	+		39
	Nassarius livescens (Philippi, 1849)	Nassa Mud Shell		+			40
	Nassarius olivaceus (Bruguiere, 1789)	Olive Nassa	+	+			41
	Nassarius camelus (Martens, 1897)				+		42
	Nassarius melanioides (Reeve, 1853)		+				43
Naticidae	*Polinices flemingianus* (Récluz, 1844)	Pear-shaped Moon	+				44
	Notocochlis (Natica) qualteriana Recluz, 1844		+		+		45
Neritidae	*Nerita exuvia* (Linnaeus, 1758)		+				46
	Neritina (Dostia) violacea (Gmelin, 1791)	Red-mouth Nerite	+				47
	Neritina coromandeliana Sowerby, 1832		+				48
Potamididae	*Terescopium telescopium* (Linnaeus, 1758	Telescope Snail	+			+	49
	Terebralia palustris (Linnaeus, 1767)	Mud Creeper	+			+	50
	Cerithidia cingulata (Gmelin, 1791)		+				51
	Cerithidia obtusa (Lamarck, 1852)		+				52
	Terebralia sulcata (Bruguiere, 1792)	Sulcate Swamp Cerith	+				53
Pyramidellidae	*Otopleura auriscati* (Holten, 1802)						54
	Pyramidella dolabrata dolobrata (Muller, 1774)	Terebra Pyram		+	+		55
	Syrnola adamsi (Tryon, 1886)			+			56
	Syrnola jaculum (Melvill & Standen, 1896)			+	+		57
Strombidae	*Canarium (Strombus)urceus* Linnaeus, 1758	Little Bear Conch			+		58
	Laevistrombus turturella (Röding, 1798)				+		59
Terebridae	*Hastula matheroniana (Deshayes, 1859)*				+		60
	Terebra anilis (Röding, 1798)				+		61
	Terebra plumbeum (Quoy & Gaimard, 1832)				+		62
	Terebra succincta (Gmelin, 1791)				+		63
	Terebra swainsoni (Deshayes, 1859)				+		64
Trochidae	*Umbonium elegans* (Kiener, 1838)			+	+		65
Sub Total	50		20	17	26	2	
Percentage	100		40	34	52	4	
Grant total	65		24	23	34	12	
Percentage	100		37	35	52	18	

4. Discussion

Other studies have also shown lesser numbers of bivalve species associated with the mangrove forest compared with gastropod species. On the west coast of India, Pawar [9] reported a total of 51 shelled molluscs of which 25% were bivalves and the rest were gastropods. Similar is the findings of Khade and Mane [10] where bivalves and gastropods constitute 37% and 63% of the 24 species recorded in Raigad district, Maharashtra, West coast of India. Unlike bivalves which mostly live in the mud (except for *E. aenigmatica*), gastropods inhabit both in the mud and trunks of mangroves, and are therefore more adapted to the very changing and harsh mangrove environment.

Among the molluscs sold in the local vending stalls, the following species have potentials for aquaculture or mariculture: *Meretrix meretrix*, *Polymesoda erosa*, *Anadara* spp. [11, 12, 13]. Exploring the aquaculture potentials of these species can help provide stable sources of income among the residents of Bucana, Iwahig, Palawan. While there is no natural stock of green mussel and large species of oysters in the area, studies dealing on the establishment of oysters and mussel farms may be explored.

Umbonium elegans occurred at very high number in the lower intertidal areas. These are sometimes harvested by the locals and sold to local shell craft makers at PhP20 per kilogram of shells (1US$=PhP43). The shells of *Placuna placenta* are also sold at PhP20 per kilogram. Sustainable harvesting of these species for shell craft industry and teaching the locals to make products out of these shells can help augment their standard of living. Other rare species may command a good price among shell collectors.

Informal conversation with collectors revealed that *P. erosa*, a commonly harvested clam that inhabits the upper reaches of the mangrove forest (*Ceriops* spp. groove) is becoming rare and smaller in size in areas close to human settlements. As a consequence, the locals are now venturing into distant areas hoping for a good catch

Nassarius pullus and *A. uropigimelana* the only common species present in the three surveyed habitats are ecologically interesting. These species, having a wider range of distribution might be a potential biological indicator for an in-depth climate change adaptation and mitigation studies. Threats to the area generally include habitat degradation and unregulated harvesting. Continuous cutting of mangrove forest pauses a threat to the existence of mangrove associated fauna. While the upper reaches of the river (which is under the jurisdiction of the Iwahig Penal Farm) are less disturbed compared to the lower reaches, continued unregulated exploitation by the inmates may affect the abundance of the commonly harvested species. Many studies have shown how unregulated harvesting and habitat degradation can threaten the molluscan population [14, 15, 16, 17]. Harvest regulation on specific size of clam and snail to exclude juveniles is needed to ensure a sustainable supply of harvestable stocks.

Improper waste disposal is another problem needing to be addressed in the study sites. Some residents throw their domestic wastes into the river. Plastic materials and broken bottles (of liquor) which pause a danger to the community are common in the port area. Oil pollution from boat discharge is evident at the lower reaches of the river which can threaten the molluscs and other fauna. Juveniles of 23 (35%) species of marine gastropods and bivalves were noted in this area that continued improper waste disposal may affect biodiversity, influence the health of the residents and its potentials for eco-tourism.

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