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Fishery status of freshwater clam (*Batissa violacea*, Corbiculidae) (Bivalvia) (Lamarck, 1818) in Cagayan River, Northern Philippines

Aeron D Mayor and Rico Ancog

Abstract
This study presents an analysis on the fishery status of edible mollusk *Batissa violacea* collected from Cagayan River, the largest river in the Philippines. The Philippine government recently categorized *B. violacea* as a threatened species due to its dwindling stocks from 2000 to 2012. Several concerns have been raised on the ongoing uncontrolled harvesting of the bivalve which could likely lead to extinction of the resource. The mean catch per unit effort (CPUE) of the bivalve was 2.04 kg/hr/boat with volume of catch ranging from 3.40-24.77 kg/trip/boat. Majority of the fisherfolk were in agreement that *B. violacea* harvested starting 2013 were of smaller sizes as compared to years 2002 and 2007. To institute concrete harvesting regulation, it is recommended that a proportion of mature individuals be left in the river so that natural breeding occurs continuously. The recommended minimum size limit of *B. violacea* to be collected should not be less than 25-49 mm. These policy regulations must be complemented with enhanced information and education campaigns among the locals to enhance their awareness on the current status of the bivalves and its habitats.

Keywords: *Batissa violacea*; freshwater clam; Cagayan River; fishery status

1. Introduction
The freshwater clam (*Batissa violacea*, Corbiculidae) (Lamarck, 1818), is a non-marine edible mollusk indigenous of Cagayan River, the largest river in the Philippines, reported to also occur across the western Pacific including Malaysia, Indonesia, Northwestern Australia, Fiji, and Papua New Guinea [16, 19, 20, 26, 27]. The clam can be found in sandy or muddy beds of freshwater and brackishwater rivers and mangrove swamps [9, 24]. This indigenous freshwater clam *B. violacea* is ecologically important and has socio-economic and cultural values [2, 16, 17] just like other mollusks [11].
However, the bivalve is currently categorized as endangered or threatened species in Cagayan River by the Bureau of Fisheries and Aquatic Resources (BFAR) Region 02 [19] because wild stocks in Cagayan River have dwindled in 2000 and continuously declined in 2012 due to over-harvesting [15]. The highest *B. violacea* production of 75.00 MT was in 2003 and declined continuously up to 21.95 MT in 2012 [6]. Hence, It has seen that continuous uncontrolled and regular harvesting of the resource may lead to resource extinction similar to several economically important bivalve species population in the Philippines such as *Anadara*, *Modiolus*, *Crassostrea*, *Placuna*, *Phacoides*, *Periglypta*, *Tapes*, *Mactra* and *Haliotis* [18], *Strombus* [10] and *Paphia textilis* [1, 14].
Hence, this study analyzed the status of the fishery of *B. violacea* in selected communities in terms of catch per unit effort and perception of collectors on abundance of the clam. This will serve as a basis in the development of conservation and management plan of the resource in order to prevent its extinction.

2. Materials and Methods
2.1 Study Area
The Cagayan River is the longest and largest river in the Philippines located in the Cagayan Valley region in northeastern part of Luzon Island and traverses the provinces of Nueva Vizcaya, Quirino, Isabela and Cagayan [25]. With an estimated length of 505 kilometers, the river's headwaters are at the Caraballo Mountains of the Central Luzon at an elevation of approximately 1,524 meters and flows north to the Babuyan Channel near the town of Aparri, Cagayan dropping rapidly to 91 meters at the river mouth. Its principal tributaries are the Chico, Siffu, Mallig, Magat and Ilagan Rivers (Figure 1).

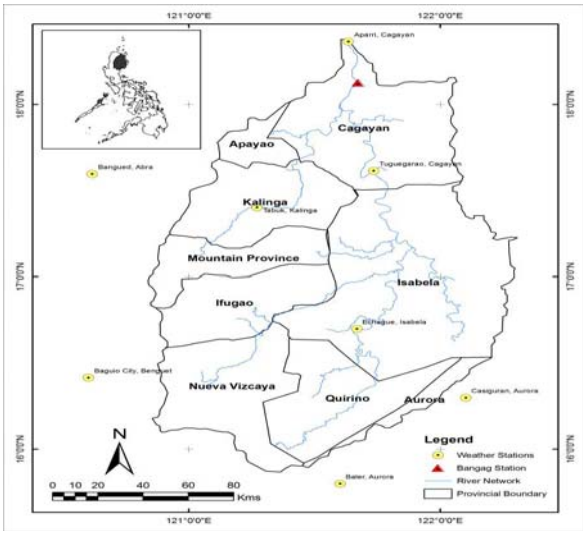

Fig 1: The Cagayan River Basin, its provinces, the Bangag Station and weather stations [25]

Cagayan River Basin falls under Type III climate zone that is characterized by no pronounced maximum rain period and a short dry period [5]. It is relatively dry from November to April and wet for the rest of the year [22].According to PAGASA (2009), the northern part of the basin has an average annual rainfall of 1,000 mm and 3,000 mm in the southern mountains. The mean annual temperature and average relative humidity are 23.6-26.00C and 75-85%, respectively [12, 25]. The river basin is relatively flat plain but is broken by low rising ridges and hummocks in some places [5]. Approximately 50% of the area is relatively flat with slope that varies from 0-17%. About 33% of the area has slopes between 17-42% while the rest are with slopes greater than 42% based on a slope map derived from the SRTM-DEM. It is also surrounded by three mountain ranges: Sierra Madre, Cordillera Central and Caraballo-Maparang in the east, west and south respectively [12, 25].

2.2 Data Collection

The fishery status of *B. violacea* in the Cagayan River was determined by conducting household interviews to randomly selected 51 collectors in 3 barangays of Lallo municipality namely: San Jose, Lallo (18°12'8.84" N - 121°39'33.09" E), Catayauan, Lallo (18°9'52.55" N - 121°39'05.31" E); San Lorenzo, Lallo (18°12'08.10" N - 121°39'31.93" E) (Figure 2.), using a pre-tested survey questionnaire. Some of the questions that were asked from the respondents include the volume of catch per trip per collector, method of collection and economic importance of the clam to the fisherfolks. The respondents were also asked to compare the volume of catch before (5 and 10 years ago) and at the present (2013). The study also determined the perception of respondents on the abundance of *B. violacea* and their suggestions to maintain the availability of the bivalves in the Cagayan River. The Catch Per Unit Effort (CPUE) was determined using the daily total catch data – total weight (kg) and daily fishing time spent for each collector.

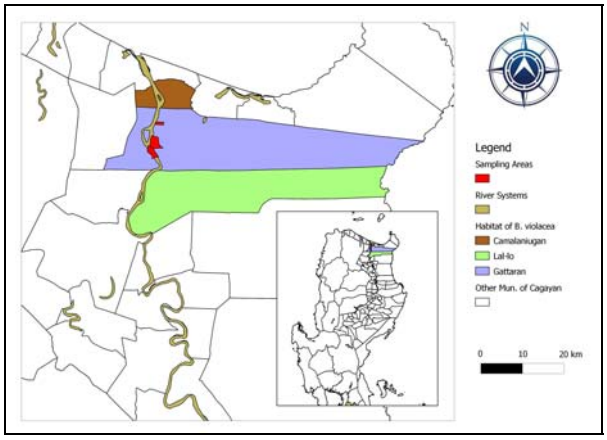

Fig 2: Sampling site of the study along the Cagayan River Basin

2.3 Data analysis

The CPUE and perception of collectors on clam abundance of *B. violacea* were analyzed using descriptive statistics.

3. Results and Discussion

3.1 Socio-demographic profile of *B. violacea* collectors

This study conducted a household interview to *B. violacea* collectors in the Cagayan River to determine the present fishery status of the bivalve in the region. The socio demographic profile of the gatherers interviewed is presented in Table 1.

Table 1: Socio demographic profile of *B. violacea* collectors in three barangays of Lallo, Cagayan, Northern Philippines.

	Barangays In Lallo, Cagayan			Mean/Total/ Range
	San Jose	Catayauan	San Lorenzo	
No. of gatherer	12	25	14	51
Average Age (year)	49.42±9.26 (29-58)	51.84±8.22 (31-63)	44.50±14.48 (21-60)	48.59
Ave. residency (year)	31.75±11.79 (20-57)	50.68±9.70 (28-63)	38.50±20.18 (3-60)	40.31
No. of years in school	8.25±3.25 (4-14)	7.22±2.99 (0.5-14)	7.79±3.60 (0-14)	7.75
Religion	Christian	Christian	Christian	-
Status	Married	Married	Married	-
No. of HH members	2-8	2-7	1-4	1-8
HH member earning income	0-3	0-1	0-1	1-3

The bivalve collectors are only concentrated in three barangays in the municipality of Lallo, Cagayan while collectors are absent or inactive in other adjacent barangays and municipalities. About 14 gatherers were interviewed in barangay San Jose, 30 in Catayauan, and 16 in San Lorenzo. The oldest bivalve collectors are observed mainly in barangay Catayauan (51.84±8.22) followed by San Jose (49.42±9.26) and San Lorenzo (44.50±14.48). Majority of the collectors are at the age range of 51-60 years old (64.41%).

The years of age of the collectors are significantly correlated

(r=0.736) with their years of residency in their respective barangays. The age is proportional to the years of residency. Overall, majority of the collectors (54.05%) are residing in their respective barangays for 51-60 years already

Generally, bachelor's degree is the highest educational attainment of the collectors while some collectors have no education. All the bivalve collectors are Christians and married with one to eight household family members in which one to three household members are earning income for the family.

Majority of the bivalve collectors depend on fisheries resource of the Cagayan River to support their family. Aside from collecting the *B. violacea*, some respondents are also involve in catching other mollusks species (*Corbicula fluminae, Delillia sp, Macrobrachium sp.)* species of crabs and fishes (*Cestraeus plicatilis, Oroechromis niloticus, Clarias* spp., *Anguilla* spp., and *Gobioides* spp.) and engaged in the buying and selling of the bivalves. The major source of living of the non-full-time bivalve collectors (35.29%) is agriculture related activities (e.g. farm land owner, farm labourer).

Other household members of some collectors are also earning income for the family. There were 14 different works by household members earning different range of income amounting to Php 200.00 to Php 9,000.00 per month. However, the collectors stressed that the salary of agricultural labourer, launderer, tailor and tricycle driver are not fixed throughout the month and depends on the availability and extent of workload to be done. Engaging in agriculture related-activities is the main work of most household members. According to latest report (1st semester of 2012) of National Statistical Coordination Board (NSCB) of the Philippines, a Filipino family of five members need Php5,458.00 monthly income to buy their minimum basic food needs and Php7,821.00 monthly to include other minimum basic non-food needs. This shows that the 13.27% household families of respondents are below the income poverty threshold reported by NSCB.

Figure 3 below shows the average collecting days per month of gatherers from last quarter of 2012 up to third quarter of 2013 which imply that *B. violacea* is present throughout the year. This is similar to the one year observation of Layugan et al., (2013) in September 1999-August, 2000 in which *B. violacea* was collected throughout the year except for the month of May. Additionally, the presence of *B. violacea* in the river throughout the year is consistent to the 12 year production (2002-2013) reported by the Bureau of Agricultural Statistics in which the bivalve production is reported quarterly [6]. According to collectors, their collection is mainly dependent to the weather condition, river water condition (high tide or low tide) and availability or abundance of the clam in the river.

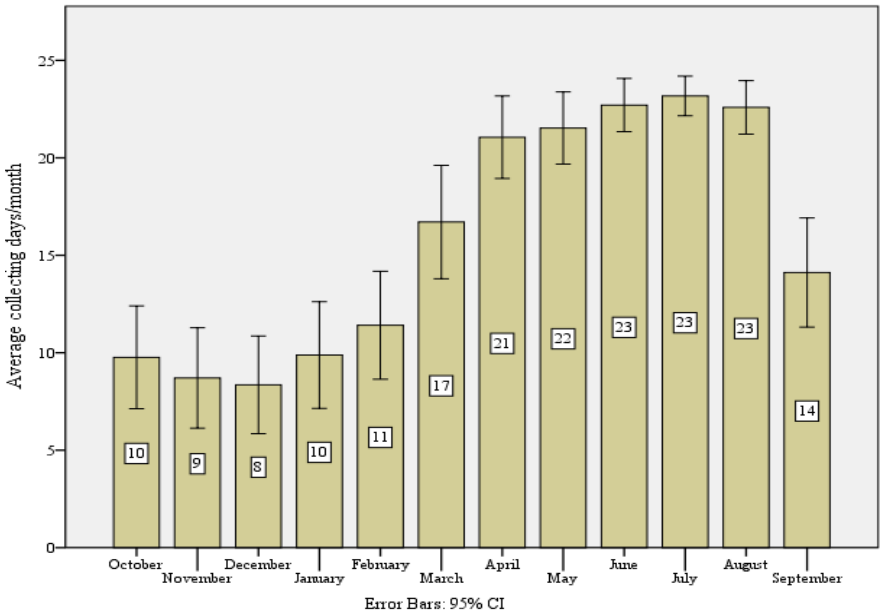

Fig 3: Average collecting days/month of *Batissa violacea* from October 2012 – September 2013.

3.2 Notes on the fishery of *B. violacea* in Cagayan River, Philippines

The *B. violacea* was found to inhabit sandy areas of the Cagayan river with a depth of 1.70-6.20 m and the bivalves increases its number when other water quality parameters are at optimum condition. Like other bivalve (e.g *Mercenaria mercenaria, Lutraria philippinarum*), the clam burrows under the sand and extend its long siphon to the surface for feeding. Thus, bivalve collectors observe the siphons of the clam in order to trace their presence in the sand, especially when the water is clear. However, when the water is turbid, the collectors trace the bivalve by its sandy substrate location and dredge the area using fishing gear *tako* to determine the presence of the clam. The collectors usually use locally dredging material *tako* and motor boat in collecting the clam because it is simple, applicable to the area, easy to use and cost effective. Collection of *B. violacea* is being done during sunny days in which water is calm, clear and the water level is low. The time of collection is early in the morning from either 6:00-7:00 A.M up to 12:00-17:00 P.M. Currently, the collectors collect the bivalves in the nine barangays of Lallo, Cagayan namely Magapit, Sta, Maria, San Lorenzo, Catayauan, Tucalana, Bagumbayan, Lafu, Fabrika and Maxingal, and in barangay Jurisdiction of Camalaniugan municipality. Although in the past, the collectors collect the clam in the barangays of Gattaran and Camalaniugan municipality when the bivalve were still abundant in those areas. The nine harvesting areas of *B. violacea*, except in barangay Magapit where in Cabibi sanctuary is situated, are open access to collectors who wish to collect the bivalves provided that they will be using a non-

destructive fishing gear. The use of destructive fishing gear "rotor" in gathering different bivalves in Lallo were prohibited since 2001 because it was seen to create disturbance to the habitat of different mollusks and other fishery resources of the river. The rotor is a machine attached at the back of the boat that stirs up the sand in order to bring out the burrowing bivalves. The bivalve is then collected as the sand pass through a small size-metal screen strainer. This kind of non-selective fishing gear damages the fisheries habitat and disturbs other organisms.

The collectors from the three barangays have a 1-2 fishing trips with 1-2 person/boat. Collectors from Catayauan has the highest catch of 5.11-26.00 kg/day among collectors because they spent more time in collection and also collect the bivalves in other areas of the river. Although some of the catch is consumed by households, the bulk of the catch is sold by the wives mostly to middlemen while other clams are sold on streets to people. The price of big clams (size Class C, D, E, F and G) is different from small clams (size Class A and B). The big clams are sold to middlemen for about Php50-80/kg while Php80-150/ganta for small clams. Then middlemen sold the clams for about Php100-150/kg for big clams and Php80-100/kg for small clams in the local markets of the province.

The average cost/trip of collecting bivalves in the river is equivalent to 19% of the average gross income/trip of collectors. The 61% of the cost of harvesting the clams are spent to fuel and 39% for the food of the collectors. The monthly average net income of collectors in collecting the clams is approximately Php10,755.49.

Most of the collectors started collecting the clams at the age of 12-15 years old, thus they have been already collecting the clams for several decades. The majority of collectors which is 41.51% are collecting the clams from 41-50 years. The 29.74% of the collectors are now collecting the clams from 31-40 years, 17.66% of collectors are collecting it from 21-30 years, followed by 9.87% of collectors collecting from 11-20 years and the rest of collectors (1.23%) are collecting the clams from about 1-10 years already.

3.3 Catch Per Unit Effort (CPUE) of *B. violacea*

The catch per unit effort (CPUE) of *B. violacea* was determined from 51 collectors in three barangays in Lallo. The mean CPUE of the bivalve was 2.04 kg/hr/boat with a range of 0.57 kg/hr/boat-4.80 kg/hr/boat. The volume of catch of *B. violacea* ranges from 3.40-24.77 kg/trip/boat. The collectors from barangay Catayauan has the highest CPUE (2.32 kg/hr/boat (0.73-4.33 kg/hr/boat) followed by San Jose (1.79 kg/hr/boat (0.57-4.80 kg/hr/boat) and San Lorenzo (1.76 kg/hr/boat (0.55-4.13 kg/hr/boat) (Figure 4). The CPUE of *B. violacea* in the river was low compared to CPUE of *B. violacea* in the Ba River, Fiji which is 11.70 kg/hr/man [16].

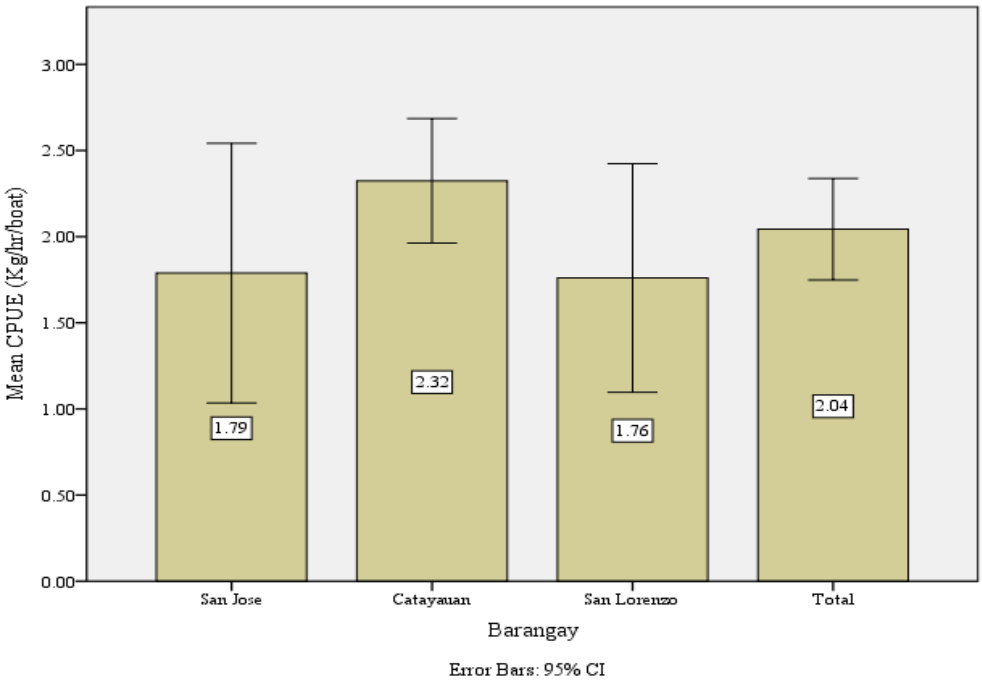

Fig 4: Catch per unit effort (CPUE) of *B. violacea* by the collectors

Although, generally the collectors have a high catch of *B. violacea* in the river from last quarter of 2012 to third quarter of 2013 as compared before, the collected clams are in smaller sizes. This suggests that the bivalve is being exploited well before it could reach maximum size. This is consistent to the result of Thangavelu et al., (2011) that shows a clear pattern of change in the size structure of *B. violacea* shells over time in the Emo (OAC), Gulf Province, Papua New Guinea. Results of their study were related to the past human harvesting impacts on *B. violacea* shell beds near Emo. The result was also in agreement with several studies that have highlighted that people have exploited shellfish for a large number of reasons (but in most instances as a source of food) and harvesting pressures exerted by people on a shellfish population is accompanied by a reduction in the size of an exploited species over time [13, 27]. This happens when the frequency of shellfish exploitation is faster than its ability to grow to full adult size [27]. Similarly, the decreased in size of harvested *B. violacea* was observed to harvested *L. philippinarum* in Negros Oriental, Philippines and in which specific collection sites became farther from the shore as compared 5-10 years ago [1]. The bigger shells contributed largely to the total reproductive

output and the massive collections of these shells can dwindle the population size of the species [1, 3]. The decrease in the shell size of *Strombus urceus* and *Strombus labiatus* in Eastern Samar, Philippines [1, 10], *Anadara tuberculosa* in Purruja, Costa Rica [1, 23] and *P. undulate* in Negros Occidental, Philippines [1, 7], indicates a worsening of the status of the bivalve fishery in the country [1].

Therefore in order to have a sustainable supply of *B. violacea* in the Philippines, it is recommended that proportion of mature individuals be left in the population to allow natural breeding to take place. Since a male *B. violacea* measuring 16mm-25mm shell length is already sexually mature with a detectable gonadal activity [15], *B. violacea* with a shell length of <16 mm is classified as juvenile while a SL of 16-25 mm and above is considered as adult. It is therefore suggested that a minimum size limit of *B. violacea* to be collected is above 25mm and the clams below this size range should be left undisturbed to allow recruitment of stocks. However, the size at sexual maturity of the clam is still uncertain, thus it is necessary to conduct a comprehensive study on the matter. Another way of resolving such uncertainty however, as a precautionary principle to avoid irreversible damage to the resource and to the community as well, could be the adoption of size at maturity of other commercially important bivalves that could be used as size limit of collected clams in order to guarantee stock replenishment in the river. For instance, the recommended useful minimum size limit (also the size at sexual maturity) of *L. philippinarum* is above 43mm-46mm and below this size range should be left undisturbed to guarantee recruitment in the area [1], earliest age of maturity of both sexes of *Arctica islandica* is about 49 mm shell length attained in 7 years [8], and both sexes of *Mercenaria mercenaria* attain first sexual maturity at ~30-35 mm SL in ~2 years at mid-Atlantic estuaries [4].

3.4 Perception of collectors on the abundance of *B. violacea* in Cagayan River

The perception of the collectors on the bivalve harvest is a qualitative assessment that may determine the abundance, availability and size of the clam. The present abundance of the bivalve in the river was compared by the collectors to its abundance five years and ten years ago. Results show that year 2013 versus 2002 and 2007 versus 2013, the clams were perceived by collectors to be more abundant at the present (Table 2). Conversely, although the clam was perceive to be more abundant today than before, all the 51 collectors noted that the size of the clam caught at present was smaller than the size of the clam caught five years and ten years ago.

Gathering of the bivalve in any forms was prohibited in the protected sanctuary located in Magapit, Lallo [21]. The 9.8% of the collectors interviewed were aware of the established sanctuary and only 60% of them said that the sanctuary is helpful to replenish clam stocks in the river. The 40% of the respondents believe that the sanctuary has no effect to the population of *B. violacea* since its occurrence is influenced by the intrusion of salt water in the river. The seedlings of the clam are being distributed by tidal current and mostly settle down at the meeting point of salt water and freshwater. However, it is unknown to collectors why the clam only inhabits in Lallo river but not in other downstream river areas. Also, the occurrence and abundance of the clam was sometimes seen as a miracle from God as He blessed the Cagayan River with abundant fishery resource for the people. Other reasons of the abundance of clam was that the unharvested clams in the past years are being harvested today.

Table 2: Perception of collectors on the present abundance of *B. violacea* as compared to 5-10 years ago.

Rank	Bivalve Collectors (N=51)	
	2013 VS. 2002 (%)	2013 VS. 2007 (%)
A lot less	29.41	21.57
Less	9.80	11.76
Same	13.73	11.76
More	45.10	39.22
A lot more	1.96	15.69
Total	100.00	100.00

In contrast, according to other bivalve collectors interviewed, the decline of clam abundance at present as compared five years and ten years ago could be the effect of on-going dredging activity in the river. These responses from the collectors were also the same to the results of survey conducted at the Rio Grande de Cagayan in September 2010 by the environmental investigation mission (EIM) team composed of non-governmental organizations (CEC-Phils., Kalikasan-PNE, Taripnong or Association of Cagayan Valley Regional Advocates, members of the Defend Patrimony Alliance among others) and some members of the Roman Catholic church in Cagayan. It was noted that local residents of Lallo, Camalaniugan and other municipalities (Buguey, Aparri, Abulug, Ballesteros, Pamplona and Sanchez Mira) in the province have already reported several negative impacts such as community displacement, receding coastline, reduction of fish catch and decreasing productivity since the dredging operation started in the province in 2006. In particular, the fish and shellfish decline was related to the possible direct effect of the on-going dredging operation to the river ecosystem to include massive siltation, destruction of fish breeding grounds and disruption of habitat of freshwater species in the river [19]. Moreover, the dredging project covers 65 kilometer stretch of the river with five phases that includes the Cagayan River's mouth in Aparri and river waters under the jurisdiction of the municipality of Camalaniugan, Lallo, Gattaran and Alcala [19].

In this study, the interviewed collectors believe that since the clams inhabit in sandy substrate; the machine use by ships in dredging could highly absorb the clams (regardless of size) and kill it by crashing. The bivalve collectors further noted that dredging was also done to shallow sandy areas of the river where the clam thrives by using a hose connected to a machine that absorb the sand. Furthermore, the low catch observed by some collectors today than before are caused by natural occurrence such as typhoon, continuous raining, weather variability and flooding. The presence of these natural occurrences limits the collectors to gather the clam in the river otherwise their life will be at risk. Also, the collectors believe that the rapid water velocity during flooding could drag the clams to sand-point bar part of the river up to the sea resulting to mortality of clams. Another reason for the low abundance observed was due to the higher number of gatherers today as compared before.

With this perception of clam abundance by collectors, they were also asked of any suggestions and recommendations to maintain the availability and abundance of the clam in the river. The 78.43% of the collectors suggested to stop the operation of dredging in the river to maintain the supply of the clam in the province while 1.96% suggested dredging only on areas where in the clams are absent. The 7.84% of gatherers responded to regulate the size of clams harvested. To allow the small clams to grow up to a marketable size which is highly valued. The 3.92% of collectors said to reserve Sunday and all

saints day as rest day in which bivalve collection is not being performed in order to allow the replenishment of stocks in the river. The 1.96% of the collectors said that the use of compressor should be prohibited in order not to collect the big clams that supply the stocks of clams.

4. Conclusion and Recommendation

In order to have a sustainable supply of *B. violacea* in Cagayan River, it is recommended that proportion of mature individuals be left in the river to allow natural breeding to take place. *B. violacea* with shell length measurement of <16 mm could be classified as juvenile whereas SL measurement of 16-25 mm and above as adult *B. violacea*. It is therefore suggested that a minimum size limit of *B. violacea* to be collected is above 25-49 mm SL and the clams below this size range should be left undisturbed to guarantee recruitment of stocks in Cagayan River.

The highest collecting days of bivalve collectors is from March to August. The collectors harvest most *B. violacea* under size class A (<25.4 mm) and class B (>25.4-38.1 mm). Hence, these months may indicate the best period throughout the year to collect seed clams for breeding and aquaculture production.

Furthermore, results of the study could provide the baseline and updated information contained in a General Management Plan (GMP). This will include the *B. violacea* fishery status; and social, economic and cultural values which are input requirements in the development of GMP of a sanctuary. The results of the study will be published and will be distributed to management authorities in order to use the scientific evidences to create a GMP for the Cabibi sanctuary and to inform other conservation and management efforts for the bivalve.

4.1 The following are recommended for future studies

1. To conduct a survey updates every after five years or ten years on the fishery status of *B. violacea* in Cagayan River to include catch-per-unit-effort (CPUE) and perception of bivalve collectors on the abundance of clams in Cagayan River.
2. The bivalve collectors claimed that seed clams of *B. violacea* are distributed by the tidal current and occur abundantly in the transition areas of fresh water and salt water of Cagayan River. It is therefore necessary to conduct a study on the mode and patterns of dispersion of the bivalves. This will include the tagging of *B. violacea* at all possible sizes to determine whether the bivalve moves upstream or downstream
3. To determine the direct and indirect influence of dredging activity to wild *B. violacea* in Cagayan river. This would include the effect of high total suspended solid (TSS) and damaged river beds as a result of dredging activity. Also, to include a survey on the presence and absence of the bivalve shells in the discarded sand from dredging process.

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6. References

1. Bantoto V, Ilano A. The reproductive biology of *Lutraria philippinarum* (Veneroida: Mactridae) and its fishery in the Philippines. Rev. Biol. Trop. 2012; 60(4):1807-18.
2. Bell JD, Johnson JE, Hobday AJ. (EDS). Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change. Secretariat of the Pacific Community, Noumea, New Caledonia. 2011, 582-614.
3. Boer W, Pereira T, Guissamulo A. Comparing recent and abandoned shell-midden to detect the impact human exploitation on the intertidal ecosystem. Aquat. Ecol. 2000; 34:287-297.
4. Bricelj VM, Kraeuter JN, Flimlin G. Status and Trends of Hard Clam, *Mercenaria mercenaria,* Shellfish Populations in Barnegat Bay, New Jersey 2012, 143.
5. BRS-DPWH. Water Resources Region No. 2 CAGAYAN VALLEY, BRS-DPWH, Quezon City, PHL. 2002.
6. Bureau of Agricultural Statistics. 2013 (http://countrystat.bas.gov.ph).
7. Campos A, Campos W. Managing the nylon shell (*Paphia undulata*) fishery off Negros Occidental. University of the Philippines, Miagao, Iloilo, Philippines, 2010.
8. Cargnelli LM, Griesbach SJ, Packer DB, Weissberger E. Ocean Quahog, *Arctica islandica*, Life History and Habitat Characteristics. Editorial Notes on NOAA Technical Memorandum NMFS-NE Series, 1999, 122-152.
9. Carpenter KE, Niem VH. The living marine resources of the Western Central Pacific. FAO Species identification guide for fishery purposes. Food and agricultural Organization of the United Nations. Rome, 1998, 150.
10. Ciasico M, Villaluz E, Geraldino P, Dy D, Diola A. Initial stock assessment of four *Strombus* species (Mollusca: Gastropoda) in Eastern Samar (Central Philippines) with notes on their fishery. Philipp. Agric. Sci. 2006; 43:52-68.
11. Crooks JA, Khim HS. Architectural vs biological effects of a habitat altering, exotic mussel, *Musculista senhousia*. J Exp Mar Biol Ecol. 1999; 240:53-75.
12. DPWH, JICA. The Feasibility Study of the Flood Control Project for the Lower Cagayan River in the Republic of the Philippines "Present River Condition, 2001.
13. Faulkner P. Focused, intense and long-term: evidence for granular ark (*Anadara granosa*) exploitation from the late Holocene shell mounds of Blue Mud Bay, Northern Australia. J Archaeol. Sci. 2009; 36:821-834.
14. Ilano A, Sotto F, Juario J. Sexual maturity and reproductive cycle of *Paphia textilis* (Gmelin, 1971) (Bivalvia: Veneroidea) off Sillon waters, Bantayan Island, Cebu, Philippines. Intl. J Aqua Sci. 2007; 4:89-103.
15. Layugan EA, Saegawa S, Laureta LV, Ronquillo JD. Gametogenesis and Spawning Induction in *Batissa violacea* (Lamarck, 1806) at Cagayan River, Philippines. IAMURE IJEC 2013; 5(0000):1-23.
16. Ledua E, Matoto SV, Sesewa A, Korovulavula J. Freshwater Clam Resource Assessment of the Ba River. South Pacific Commission, B.P D5, Noumea, New Celedonia Fisheries Division, P.O Box 358, Suva, Fiji, SPC Integrated Coastal Fisheries Management Project Reports Series #1, 1996, 1-31.
17. Lewis AD. (ED.). Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji 1985A, 1-90.
18. Luchavez J, Abrenica B. Fisheries profile of Bais Bay, Negros Oriental. Silli. J. 1997; 37:93-137.

19. Mayor AD, Ancog R, Guerrero III, RD, Camacho Ma.VC. In Press. Environmental factors influencing population density of freshwater clam *Batissa violacea* (Bivalvia) (Lamarck, 1818) in Cagayan River, Northern Philippines. Intl. J Aqua Sci. 2016.
20. Morton B. Do the Bivalvia demonstrate environment-specific sexual strategies? A Hong Kong model. J Zool 1991; 223:131-142.
21. Municipal Ordinance of Lallo No. 05-2005. An ordinance designating one and a half kilometer length of Cagayan River within Lallo from the boundary with the municipality of Gattarran as a Cabibi Sanctuary, 2005.
22. PAGASA. Hydrometeorology Basin Information - Cagayan River Basin, 2009.
23. Pirlot A Wolff. Population dynamics and fisheries potential of *Anadara tuberculosa* (Bivalvia: Arcidae) along the Pacific coast of Costa Rica. Rev. Biol. Trop. 2006; 54:87-99.
24. Poutiers JM. Bivalves. *Acephala, Lamellibranchia, Pelecypoda*. In Carpenter KE, Niem VH. 1998; 199:123-362.
25. Principe JA. Exploring climate change effects on watershed sediment yield and land cover-based mitigation measures using swat model, RS and GIS: case of Cagayan River Basin, Philippines. ISPRS Archives 2012; XXXIX:193-198.
26. Richards A. With contributions from Maciu L, Subodh S, Krishna S. (Compilers). FIJI FISHERIES RESOURCES PROFILES. FFA Report No.94/4 1994.
27. Thangavelu A, David B, Barker B, Geneste J, Delannoy J, Lamb L *et al*. Morphometric analyses of *Batissa violacea* shells from Emo (OAC), Gulf Province, Papua New Guinea. Archaeol. Oceania. 2011; 46:67-75.