Giant Clam Conservation in Sabah: a need for the appreciation of the Bajau people’s traditional ecological knowledge

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Abstract. Kima (Tridacna sp.) is a type of giant clam that can be found in Indo-West Pacific tropical coral reefs. It is endangered due to its excessive exploitation as a source of exotic food and the degradation of its habitat. The gazette of marine parks in Sabah is a positive modern conservation effort to reduce threats on endangered marine species especially those found in the northern part of Sabah. Integral to the conservation of giant clams within those marine parks is the appreciation of indigenous knowledge of once known sea gypsies i.e. the Bajau people. Current conservation methods at several sites in Sabah’s marine park had shown several challenges, which circulate tension among the economics of local communities. To explore the possibility of appreciating indigenous knowledge into the conservation of giant clams, a scientific study with the objective of documenting traditional consumption method of the Bajau people was carried out. Direct observations and interviews on the local people were conducted, while descriptive statistics were used to analyse all collected data. Finding of this study shows the existence of traditional ecology knowledge (TEK) and traditional management among Bajau people pertinent to the conservation of Kima. TEK can complement conventional science and help to make more informed management decisions for clam conservation through for hybridization of modern and traditional management to customary management in managing and conserving giant clam population in Sabah’s marine parks. A synthesized advice to use traditional ecology knowledge as tool in developing more effective knowledge-inclusive partnerships between indigenous communities, researchers and policy decision-makers is provided in this article.

Keywords. Traditional ecological knowledge, Sabah’s Marine Park, indigenous community

1. Background
The relationship between local communities and giant clam in Sabah is present at various levels. While in some places, giant clam is considered dangerous marine bivalves, in others they may be considered sacred animals and may even serve as tourist attraction. Local community like Bajau people and giant clam share remarkable relationship from the ecological to the cultural level [1]. However, perception of giant clam in local community may vary according to how they relate to each other. Understanding the conflicts between giant clam consumption for human benefits and the needs of giant clam conservation to protect the wild population involves studies aiming to understand the need of these two groups [2]. This resulted in the application of ethnobiology, which is the discipline studying the dynamic of the interactions between giant clam consumption and Bajau people in Sabah.
In the search for appropriate resources management, there are many researches aiming to study consumption of the resources for economic and financial purposes. Among of these management is aquaculture method, community-based management and Protected Areas (Pas) method are by far those maintaining modern conservation and additional resources as a replacement from extracting resources from wild population or habitat [3]. Giant Clam population size and the distribution patterns are directly to the structure of the marine environment such as coral reefs, depth of the coastal areas they inhabit and to the allocation of resources in these areas [3]. Therefore, anthropogenic landscapes alteration, including over-harvesting the giant clam resources may directly influence the size, distribution and abundance of the giant clam population [2]. Thus, the interfaces between human consumption and clam resources ultimately resulted in a complex network of ecological, epidemiological, and economic relationships [2]. However, the main conflicts arise from the needs on consuming and the need to protect giant clam resources in Sabah. The current fields, consumption in economic views and conservation of the resources, would present difficulties to understand more precisely the relationships between local consumption and conservation of giant clams. These difficulties seem to be limitation of both fields: while conservation focus more on the current modern efforts to conserve and increase the population of clam resources and exclusively ignoring the rights of local community or indigenous people on utilizing the resources, consumption in economic views focuses on the method to consume and generates financial benefits from the clam resources. Thus, there is the need for a field allowing a research approach which specifically addresses the relationship between humans and the clam resources.

1.1 Introduction
Vast fields of studies have been conducted over the years on bivalves all over the world. In majority, it focuses on country statements, stock assessments and conservation, reproduction, culture methods, physiological aspects, culture techniques, growth, growth and production rates, predators, parasites and diseases and socioeconomics, especially on giant clams, *Tridacna* sp. Regardless to vast studies range of clams, only a handful are relating to ethnobiological studies, including in Sabah. Examples of ethnobiological research on clams can be seen from extensive research program for giant clams by Lucas and Copland (1988). Their works on compilation of giant clam research for The Australian Centre for International Agriculture Parliament (ACIAR) in 1988 comprises bits of ethnobiological information from the country statements. The ethnobiological information on giant clams discussed the direct values of giant clams to the local people, through productive and consumptive utilization. Productive utilization of giant clams consists of aesthetics and ornamental; medicinal and economic benefits. While, consumptive utilization was the use of giant clams for personal needs and foods. Giant clams that were massively exploited and commercialized for economic and exotic food. However, giant clams were still abundant in protected areas but still illegally trade and harvested.

Giant clams have a high potential in market due to its exotic and aesthetic traits. It is quite popular for illegal aquarium trade, ornamental shell trade and consumption purposes that are exotic and rare because of its low population in the wild. These market benefits also caused the conservation and protection efforts of giant clams inefficient. The consumer demands lead to illegal export and harvest of wild giant clams from protected area. As the population of giant clams in the wild decreased, the density of mature clams also decreases, disturbing breeding process and population become reproductively dysfunctional, contributing to a total collapse of the population and extinction. Therefore, improvised methods are needed in the conservation and protection method of giant clams in Sabah. Through integration of traditional knowledge by Bajau people and the scientific knowledge could lead to a new improvised step in protecting and management of the giant clam population. With the help of local community, monitoring purposes could be intensified while, providing economic benefits to the local community. The community are able to use the marine resources in an appropriately way, while protecting their resources from depleting. However, to ensures the
effectiveness of this method, more information on the Bajau traditional knowledge and the biology of giant clam in Sabah need to be studied and properly documented for conservation and management purposes.

Clam conservation in Sabah is generally carried out protecting particular location through gazette an area that is important for the clam growth and population, supervised by Sabah Park. Some of gazette area were specified into specific zones with different functions and regulations, while some of it, were commercialized into tourism sites and clam’s research center. The park was placed under International Union for Conservation of Nature (IUCN) Category VI protected area, but with sustainable use provisions which allowed communities to live and continue their activities within designated zones. Clam conservation in Tunku Abdul Rahman Park are carried out in in Marine Ecology Research Centre (MERC) in Malohom Bay of Gaya Island aiming to produced life of threatened and endangered species that are likely destined for extinction through giant clam propagation program and coral reef restoration. Activities such as nursery and re-stocking giant clams in the sea were active efforts in MERC due to giant clam biological processes that possessed slow growing and minimal defense system. Therefore, conservation of giant clams is highlighted through nursery, restoring coral reefs and environment education. Tun Mustapha are the largest marine park in and are significant for marine conservation [4] in Malaysia. In Tun Mustapha Park, giant clams is utilized by local people for foods, economic activities or cultural value aspect [5]. However, the biodiversity in Tun Mustapha Park is threatened due to Malthusian overfishing in Banggi island causing the declining of fisheries resources [5] resulting to the conservation efforts on the biodiversity in Tun Mustapha Park that incorporate local or indigenous people that utilize the natural resources in the park. Giant clam conservation at Tun Sakaran Marine Park were mainly located in Giant Clams and Marine Invertebrate Hatchery (GCMIH) in Bohey Dulang island [6]. The main objective of GCMIH are to provide the local community of an opportunity in aquaculture that turn out to be an alternative livelihood program [6]. Community that lives in Tun Sakaran Marine Park usually harvest and utilize giant clams for economic and daily purposes, thus, resulting in GCMIH planned to continue in conducting research and cultivate giant clams with seed supplied to the local community to help them to reduce their over-reliance on natural marine resources through underwater giant clams eco-trail and sustainable commercialization for trade purpose in the long term [6].

The ethnobiological information from the journal recorded various utilization of giant clams, includes the customs and beliefs, traditional usage, food, utilization crafts (such as ash trays, ornamental) and so forth [3]. Most of the exploitation of clams are tied up with delicacy reasons and are related to nutrition supplies for the body. While, exploitation in modern age are more related to increase in livelihood associated with economic struggle faced by the local community or high demands of the resources for consumption purposes. For example, consumption of clams is highly practiced near the coastal areas, which is a destination for tourist, locally or internationally [3]. As these areas become the main production in utilizing the clam resources for the demands, thus, providing chances for local community to improve their livelihood. Nonetheless, without proper management, exploitation of clam resources could threaten the entire giant clam population. Therefore, there is a need in consideration of other management or conservation methods to balance the economic and conservation activities in Sabah.

Despite the popularity of clams as seafood products among international and local tourists, the ecological functions and population clams are least documented and studied in Sabah [6]. Therefore, traditional ecology knowledge can be integrated into the management of the island marine resources in sustainable manners [7-10]. In this case, traditional ecology knowledge of Bajau people is vital for the management of giant clams because they utilized this resource for foods and cultural values [11-13]. Traditional knowledge as well as anticipation of Bajau people could be including in conserving the giant clams or marine biodiversity in Sabah with suitable conservation method.
2. Literature Review

2.1 Clam Biology

Giant clams characterized with soft body and protected by hard shell, surrounded by heavy fold of tissue called mantle that encloses their internal organs, connected by each other with hinge. The largest species of giant clam, Tridacna gigas have shell lengths of over 120 cm and 200 kg of weights [3][14-15]. Giant clam range in size from about 35 cm of Hippopus porcellanus compared to the largest giant clams of South Pacific coral reefs, Tridacna gigas, which estimated to be more than 137 cm in length and weigh more than 300 kg. The mantle of giant clams is brown, and all soft tissues of giant clams are edible except for the kidney which accumulated with arsenic and heavy metals [3]. Developed siphon tissues cause numerous small blue-green circles, containing zooxanthellae [3] that operates under the sunlight for photosynthesis process [3]. These symbiotic algae help giant clams in photosynthesis mechanism for filter feeding contributing to the gigantic size and faster growth rate of the giant clams [3]. The family Cardidae consist of 13 extant species with vulnerable (VU) status [15]. Tridacna maxima or Tridacna gigas is the most common and widespread species, while Hippopus porcellanus, Tridacna mbalavuana, T. Ningaloo, T. Noae, Tridacna rosewateri and T. Squamosina have much more rare and restricted distributions [15].

Giant clams are highly distributed around coral reefs, especially in Indo-West Pacific [15]. These clams usually inhabit an area that are able to be reached out by sunlight and tropical coral reef due to their mutualistic relationship [15]. Coral reef possessed calcium carbonate framework that is maintained by opposing processes of the production and removal of carbonate and giant clams act as bioeroders that increase the removal rate of the reef’s carbonate framework [15]. Their tropical distribution in coral reef are also related to light intensity [3]. It is expected that giant clam has higher abundance and distribution in areas with large activity of fishing activities as it is crucial for food sources for local people. Local people fishing activities occur in an area that occupied with large food resources, especially in coral reef, thus this leads to conclusion that giant clams are one of the food resources in coral reef areas [4-5]. There are nine species of clams worldwide and seven species of giant clams distributed in Sabah. According to My Sabah website, Tridacna gigas, Tridacna derasa, Tridacna squamosa, Tridacna maxima, Tridacna crocea, Tridacna porcelanus and Hippopus hippopus populated Sabah’s coral reef and, Tridacna gigas and Tridacna derasa has been considered critically endangered and locally extinct in Sabah.

2.2 Ethnobiology and Conservation

Ethnobiology have a wide range of aspects from cultural to biological, including the study of diverse relationships [2]. Generally, it is defined as the study of the interactions of people and the environment [2]. Ethnobiology approach mainly on associating knowledge of natural sciences and knowledge of human sciences to record and document the knowledge, classification and use of natural resources from different cultures [2]. Thus, one of the heavily focused by ethnobiologist are the traditional knowledge or local knowledge that are dynamic and changeable, formed from the interaction of living beings and their habitats. According to Albuquerque and Alves (2016), there are two classical approaches in ethnobiology, which is cognitive and economic. Cognitive approach highlighted on how cultures perceive and know biological world, while, economic focused on how cultures convert biological resources into useful products [2] to gain benefits for their livelihood. Ethnobiological information is gathered from the interaction of human population with plant or animal resources, contributing to the biodiversity conservation and sustainable use, giving credits to the knowledge and rights of traditional knowledge of local peoples [2]. Through this information, the quality of environment and livelihood of local people could be developed and enhanced through sustainable approaches. In relation to the ultimate goals of ethnobiology approach, traditional ecology knowledge is known as accumulated experiences and knowledge by a human group in relation to natural resources [2]. However, this type of knowledge has been underestimated in the aspect of scientific study, leading to the development of alternatives to current paradigms with beneficial aspects for the
advancement of scientific or academic knowledge [2]. Ethnobiology information for an instance, could help in conserving and protecting the wild population of giant clam, through the patron of experienced local people. In this way, giant clam conservation could be developed and enhanced, including creating public awareness and environment education to the publics. Ethnobiology studies also become the middle line in association with local peoples and decision makers to define and ensure conditions for the socially appropriate distribution of the benefits of the studies in which these people participate [2]. This is important especially in considering the role of local people (Bajau people) and giant clam conservation in Sabah creating a concrete role of the community in this effort. Therefore, ethnobiology approaches in this study encompasses various types of actions related to conservation, traditional property rights in utilizing marine resources and cultural aspects of development[2]. Ethnobiology information on this study are important because of its potential to integrate local and global knowledge, to connect traditional cultures and modern approaches and to relate biological and social aspects of the human experience to the environment.

2.3 The Bajau People
Bajau or Sama are known as boat nomads or sea nomads, which lives at the sea with a boating life in a nomadic way of livelihood. According to Sendera and Yakin (2013), this community also known as sea gypsies, waju and other variation of pronunciation of the term Bajau, as Badjaw, Bajo, Badjoo, Bajjau and others. While in Sulu, the Bajau is also known as Sama, Samal, Palau, Kaliaggeh and Luwaan. But Bajau-Sama are often used in Sabah to represent these ethnic groups [12]. According to Sendera and Yakin (2013) documentation of Bajau origin can be traced in the middle of the 20th century researchers that are actively write and published books or articles on the West Coast Bajau community, but Sendera and Yakin (2013) mentioned that the documentation on Bajau cultures were still lacking and less prolific. In order to integrates Bajau cultures that could be beneficial in handling marine resources, more studies should be done especially the interaction of Bajau community with their environments.

Generally, Bajau ethnics could be found in several regions in Southeast Asian, becoming indigenous people in these three countries: Philippines, Indonesia and Malaysia [12]. Bajau ethnics in Sabah occupied in two major settlements: district of Kota Belud on the West Coast as well as the district of Semporna, on the East Coast [12]. Besides Kota Belud, the Bajau in West coast can be found from Kudat Peninsula, Tuaran, Kota Kinabalu, Sepanggar, Putatan to Papar [12]. While in the East sides, the Bajau community also occupied in the island of Omadal Island, Siamil Island, Bum-Bum Island and among others [12]. Bajau people are also described to be spreading across several other regions in Southeast Asia and is perceived as large scattered ethnic group who generally occupied the islands of Southeast Asia [11]. Sendera and Yakin (2013) quoting to past study on the estimation of Bajau population in this continent between 750,000 to 900,000 people. Therefore, Sendera and Yakin (2013) estimated that they are probably more than one million Bajau people nowadays and even more in the future. Sendera and Yakin (2013) concluded that there are 165,3224 Bajau people from both East and West Coast in Sabah, including the Federal Territory of Labuan. The current population of Bajau people has probably increased but there is no study document on these matters.

Bajau people permanently occupied ashore-strand of villages along the coast or islands like in Semporna region [11]. Early in Bajau community development, they were nomadic, moving from one place to another to find fertile fishing ground. As development and modernization progress, they slowly sedentary and settled on land [11]. Some of the Bajau occupied the land for crop plantations and commerce activities, however there are still large portion of Bajau people that rely on fisheries for economic purpose [11]. Ismail (2015) explained that most of the Bajau people that still rely on the sea were mostly from West Coast Sabah. He mentioned the reason for Bajau community that rely on the sea are because their skills are limited to the skills they have inherit from their parents [11]. This was mainly related to the productivity of land and their transportation method, in addition with settlement that were built along the coasts, befitting their lifestyle. Most of the Bajau community that are
nomadic built temporary settlement in coastal areas, while harvesting marine resources that are abundance and seasonal [11]. Once the seasonal marine resources have passed, they changed into another location for other marine resources. This shown that Bajau community are highly tied with the environment as the way of their life. Cultural and traditional knowledge of the Bajau people are highly valuable in managing marine resources as their cultures could preserves values on human-environment interaction and the necessity in protecting it, while gaining appropriate benefits from the nature.

2.4 Ethnobiology of the Bajau People
According to literature reviews, Bajau people are highly dependent on marine resources, this included giant clams. Bajau people often involved in a diverse maritime-related livelihood as hunters and gatherers, fishers, sailors, boat builders and traders [16], indicating the skills they have in harvesting giant clams. They also possessed an intensive knowledge of the inshore and offshore marine habitats and their associated resources, including climatic factors such as seasonal changes, winds, currents, tides, lunar cycles and navigation [16]. Their maritime lifestyle on utilizing marine environment are interrelating with their custom beliefs. Bajau people encompasses a deep marine cosmology based on belief in a spirit who inhabits the sea and exercise causal influences upon human beings and their environment [16]. They belief that overharvesting the marine resources leads to the wrath of sea spirits and thus, causing environment disasters [16].

Align with Bajau culture, collecting mollusks usually done by women and children because it is closer to the shore, then, involve in selling the resources to the tourists [16]. While the men are involved with fishing, however, due to the No-Take-Zone (NZTs) for marine parks, the Bajau people, especially fishermen are force to fish in the pelagic zones within marine protected areas (MPAs) and the deeper waters outside these MPAs [16]. Despite the efforts in conservation and protecting marine environment, the Bajau people are being torn in following the conservation efforts and their livelihood necessity. There is lacking information on the utilization of giant clams (Kima) in Sabah. Therefore, most of the information gained are based on general knowledge of Bajau people on harvesting marine resources. This research focuses mainly of the utilization of giant clams by Bajau people in Sabah.

3. Methodology
To obtain traditional ecology knowledge of Bajau people on giant clam consumption, semi-structured interviews and open-ended questionnaires were conducted with Bajau people or people that occupied within Bajau community. The interviews also included people and government officers that are involved in giant clam conservation efforts. Quantitative methods such as descriptive analysis was used in data analysis.

3.1 Study Site
The semi-structures interviews and open-ended questionnaires were conducted in four main sites that are involved in giant clam conservation and clams trading. Giant clam conservation in Marine Ecology Research Centre (MERC) in Malohom Bay of Gaya Island, Banggi Island of Tun Mustapha Park (TMP), Wet Market of Sandakan and Fisheries Department of Kota Kinabalu. These sites were chosen because the conservation area emphasized on the giant clam propagation program and coral reef restoration. Activities such as nursery and re-stocking giant clams were currently the most active in these areas, individual that are involved directly in the effort of giant clam conservation were interviewed. Field interviews targeted Bajau communities, people that occupied Bajau communities and individual that are involved in giant clam professions, as these were the three stakeholder groups with highest potential for interaction with giant clams. Government officer were interviewed to gained their perspective as their professions in managing marine resources. Giant clams also are food resources for local people [5] such as the Bajau people. Therefore, location that are occupied with Bajau people and seafood trading activities also included to gained their traditional knowledge, and these community were the main targets.
3.2 Bajau Community Survey
There were two purposes for the Bajau community surveys: 1) to determine the clam traditional knowledge of the Bajau ethnicity; and 2) to identify traditional clam management in Bajau ethnicity. The survey consisted of a two-page questionnaire which included questions about the activity of collecting giant clams, cooking method, consumption of giant clams and perspective of Bajau community in giant clam conservation. Survey were available in Malay, and were distributed at three locations: Bangi island of TMP, Wet market of Sandakan and Kota Kinabalu. Respondents were requested to fill the questionnaires directly or through online questionnaire. In total, 204 surveys were filled, and 55 surveys were used for this paper.

3.3 Field Interviews
In total, 204 questionnaires were completed in March 2018 and September 2019, but only 55 questionnaires and two individuals were interviewed for this research. Interviews were conducted in Malay and English according to their professions. First interview was conducted in March 2018, which is the chief leader of a town in Bangi island, TMP, while the second interview were conducted on November 2019 with the project manager of MERC in Gaya island. The interviews followed a semi-structured format; questions focused on the giant clam conservation, local knowledge on giant clam consumption and their utilization in Bajau community. Each interview took 30-60 min to complete. Participatory method in understanding Bajau traditional ecology knowledge on giant clam consumption were also conducted.

3.4 Direct and participant observation
Direct observation is used to observe the interaction of traders with the buyers. This method could help in gaining additional information on the giant clams as the traders promotes it to the buyers. It is an appropriate in situation where accurate information cannot be elicited by questioning the respondents. Participant observation are also used to engaged in giant clam consumption as exotic cuisine. The results of participant observation are used to triangulate data in supporting the interviews of the respondents.

4. Results
The data were analysed using quantitative methods to determined and identify the TEK of Bajau people. Descriptive analysis [2] was used to calculate the percentage and formed pie chart and bar chart on the surveys data. Pie chart are used for nominal and ordinal data while, bar chart is used for interval-ratio variables, tables are used for concluding the data. These methods help in showing the difference in percentages among the categories of a nominal or an ordinal variable in the most simplistic ways for presentation.

4.1 Demographic of the respondent background
The data collected 55 responses from the three location. There are 53% of female respondents and 47% of male respondents of Bajau people and local people that lives in Bajau community. 5% of the respondents came from Kota Kinabalu, 56% came from Sandakan and 38% came from Tun Mustapha Park (TMP). In terms of age category, majority of the respondents (62%) were in more than 40 years old. While, second highest (16%) are in the age of less than 25 years old. 15% came from 25 to 30 years old and the lowest two came from 31 to 35 (5%) and 36 to 40 (2%) years old. The graph above shows the percentages of respondent’s ethnicity with nine types of ethnicity recorded during the interviews in Banggi island. The recorded and percentage of ethnicity is 65% of Bajau, 4% of Bajau Bengingi, 2% of Bajau Sama, 2% of 5% of Bajau Suluk, 11% of Bajau Ubian, 2% of Jawa, 5% of Kegayan, 2% of Malay, Suluk and 2% of Sungai. Majority of the ethnicity are dominated by Bajau people because of the selected area that have concentrated Bajau people for this research.
4.2 The respondents understanding about Kima

Table 1. Data collection on giant clam consumption based on respondents

| Question                                      | Scale | Percentage | Total |
|-----------------------------------------------|-------|------------|-------|
| Giant clam meat consumption                   | Yes   | 93%        | 100%  |
|                                               | No    | 7%         |       |
| Giant clam as traditional food                | Yes   | 93%        | 100%  |
|                                               | No    | 7%         |       |
| Increase in clam consumption in the area      | Yes   | 44%        | 100%  |
|                                               | No    | 56%        |       |
| Clam consumption are important                | Yes   | 87%        | 100%  |
|                                               | No    | 13%        |       |
| Clam conservation are important               | Yes   | 85%        | 100%  |
|                                               | No    | 15%        |       |
| Aware of clam conservation in the area        | Yes   | 82%        | 100%  |
|                                               | No    | 18%        |       |
| Pollution activity in the area                | Yes   | 85%        | 100%  |
|                                               | No    | 15%        |       |

Majority of the respondents consumed giant clam meat (97%), only small percentage (3%) did not consume giant clams due to several factors. Most of the respondents viewed giant clams as their traditional cuisine (97%), while small portion did not view it as traditional cuisine (3%). Most of the respondents agree that there are increased in giant clam consumption in their area (44%), while (56%) disagree, this also correspond with there are decrease in giant clam population according to the interviews. (87%) of the respondents agree that clam consumption is important, while (13%) disagree. The survey also revealed that 85% of the respondents agree that clam conservation is crucial to the local community and 15% disagree. 82% of the respondents aware that there are aware of clam conservation in the area, 85% aware that there is pollution activity in the area, 15% did not aware of it.

4.3 The respondents’ relationship with Kima

Pie chart A shows 76% of the respondents that collect giant clams. This occupied by old generation and some of the young generation that are taught by the older people. 24% of the respondents does not collect giant clams because they did not consume it and due to low population of the giant clams in their area. Pie chart B shows three types of methods in collecting giant clams based on the Bajau ethnic. 76% respondents mentioned on collecting giant clams using hand but this method depends on the location. Easily accessed area that is occupied by giant clams would be collected using hand only. While, giant clams that are attached to some substrates such as coral, sand or rock, would be collected using simple equipment. 10% of the respondents used equipment to collect giant clams. 14% are unsure because they never participated in collecting giant clams. Pie chart C shows three main methods in cooking giant clams. 71% are unsure because they seldom consumed giant clams due to low population of the giant clams, this mainly are the young generation. While, 24% mentioned raw cooking method and this is mainly the old generation. 5% mentioned cooking method, in addition with
utilization of seasonal, this were mostly mentioned by housewives. Pie chart D below shows criteria in collecting giant clams. 19% of the respondents mentioned sizes. They prefer large size over small size to feed their family. This also related to the size of their family. They often released small size for it to grow. 5% choose abundance and distribution because some of them are limited in swimming ability. Giant clams are more abundance and distributed in shallow area over the sea due to their symbiotic relationship that require sunlight. Another 5% choose size, abundance and distribution. Similar with the limited ability in swimming but they also choose large size of small for giant clam growth opportunity. 66% did not stated because some of them does not have any criteria in collecting giant clams.

![Pie chart A](image1.png)

**Figure 1.** (Pie chart A) The percentage of respondents that collect giant clams.

![Pie chart B](image2.png)

**Figure 2.** (Pie chart B) The percentage of giant clam cooking methods by the respondents.

![Pie chart C](image3.png)

**Figure 3.** (Pie chart C) The percentage of methods in collecting giant clams by the respondents.

![Pie chart D](image4.png)

**Figure 4.** (Pie chart D) The percentage of respondents in accordance to their criteria in collecting giant clam.
4.4 Bajau Traditional Ecology Knowledge (TEK) on giant clam consumption

Bajau TEK on giant clam consumption were mainly due to cultures and tradition. Still, based on the conducted interviews, reasons for the tradition of giant clam consumption were due to (a) availability of giant clam in their areas, and (b) perception of benefits provided by giant clam consumption to vitality and milk production by breastfeeding mothers.

4.4.1 Availability of giant clam

According to the interview with Bajau people, consumption of giant clam in some of their traditions such as wedding ceremonies, kenduri or daily consumption depend heavily in the availability of giant clam in their area. The community do rely on other marine resources such as fishes, sea urchins, crabs and prawn, but giant clam were one of their highlight cuisines in important tradition. However, respondents mentioned that giant clam were hard to be found and collected in the shallow coastal area. This is due to overharvesting of the resources, leading to decrease in the population of giant clams in the wild. Hence, if the availability of giant clam were low in that seasons, Bajau people utilize and consume other marine resources. Despite their tradition in collecting giant clams for consumption purposes, they have several criteria in choosing giant clam and one of the most important criteria are the size of giant clams. Majority of the respondent mentioned that they do not collect juvenile or small size giant clams for consumption purposes. Juvenile or small size clams were collected only to be kept until it achieved appropriate size to be consumed. Seeing the vulnerability of giant clam population in the wild habitat, MPAs zone or the no-take zone was established to monitored and protect the population of giant clams from being harvested. It is interesting to note that local community such as Bajau people still harvest and consumed giant clams from the MPAs as their food resources.

4.4.2 Perception of benefit provided by giant clams to the Bajau people

Giant clam is considered traditional food and is often consumed in the past as well as the then current period. Further interview shows that Bajau people believed that giant clam are able to helps in milk production for breastfeeding mothers. These perceptions were popular among interviewed Bajau housewife and elderly people but not with fishermen:

"Inda juga kami pasti, tapi biasanya kima ni dimakan supaya boleh kasih susu anak. Kasi banyak air susu orang bilang.

“We are not that sure, but usually giant clams were eaten so that it can help in child breastfeeding. People says that it helps in producing a lot milk for breastfeeding mothers.”

While, fishermen believe that giant clam are important for vitality and is used for aphrodisiac. These data have similarity with the TEK beliefs of local people in Indonesia that consuming giant clams to help in breastfeeding the new-borns [14]. However, there is no scientific records on giant clams as traditional medicine that could help in breastfeeding new-borns. Despite, these perceptions exist among Bajau people as TEK practices, there are also Bajau people mentioned that giant clams do not have any other importance than as a protein source for the community. Instead, it should be consumed in small amount because they suspect that it can cause high blood pressure and severe allergic effect for individual that are allergic with seafood. Thus, giant clams were mainly eaten for protein source and daily routine.
4.5 Bajau People’s Perspective about the need to conserve giant Clams

Table 2. Perspective of the respondents that occupied Tun Mustapha Park on Giant Clam conservation from questionnaire set A.

| Questions | Items                                      | Strongly disagree | Disagree | Neutral | Agree | Strongly agree | Total   |
|-----------|--------------------------------------------|-------------------|----------|---------|-------|----------------|---------|
| 1         | Giant clam is very beneficial for health.  | 19%               | 5%       | 24%     | 10%   | 42%            | 100%    |
| 2         | Giant clam is sold with high price in the market. | 19%               | 0%       | 14%     | 0%    | 67%            | 100%    |
| 3         | Giant clam is very important food sources.  | 33%               | 0%       | 10%     | 5%    | 52%            | 100%    |
| 4         | Harvesting would decrease the giant clam stocks or population. | 24%               | 0%       | 19%     | 5%    | 52%            | 100%    |
| 6         | Conserving giant clam is important.        | 10%               | 0%       | 5%      | 0%    | 85%            | 100%    |

Table 2 shows the perspective of the respondents in TMP on giant clams as food resources. These questions were answered along a 5-point Likert scale, from 1 (strongly disagree) to 5 (strongly agree). The questions highlighted the beneficial of giant clams, the prices of giant clams, giant clams as important food sources, effect of harvesting giant clams and the conservation of giant clams. Majority of the respondents agree heavily on the questions above because of certain factors such as food sources, giant clams as their traditional cuisine and low population of the giant clams in their area. While some of the respondents disagree because they mentioned the availability of other foods in replacing giant clams as food sources. They also mentioned health issues due to consuming giant clams and low population of giant clams caused them to choose other food resources.

Table 3. Perspectives of the respondents on giant clam conservation from questionnaire set B.

| Questions | Items                                      | Strongly disagree | Disagree | Neutral | Agree | Strongly agree | Total   |
|-----------|--------------------------------------------|-------------------|----------|---------|-------|----------------|---------|
| 1         | The government is providing enough (economic incentives) support for clam conservation. | 6%                | 8%       | 15%     | 9%    | 62%            | 100%    |
| 2         | Clam conservation should be stricter.      | 0%                | 15%      | 38%     | 6%    | 41%            | 100%    |
| 3         | Willingness to be part of clam conservation efforts. | 0%                | 12%      | 44%     | 12%   | 32%            | 100%    |
| 4         | Aware of clam conservation effort or activities in Sabah. | 6%                | 0%       | 12%     | 29%   | 53%            | 100%    |

The following data were collected based on respondent perspective on clam consumption from questionnaire set B (eight questions). The questions emphasize on supports for clam conservation from...
the experience and perspective of respondents. Main points for the question were support for clam conservation, the degree of conservation efforts, willingness to participate and awareness of the clam conservation. Majority of the data concluded in agreeing side because some of them are aware of the economical from clam utilization. While, some of them aware of the giant clam status in the wild habitat. Second highest responses came from neutral categories because they are unaware of the giant clam status and aware of the other choices of food resources. Minority of the respondents choose to disagree because of availability of other food resources.

Table 4. Perspectives of the respondents on clam conservation as part of the traditional culture (Bajau ethnic) from questionnaire set B.

| Questions | Items                                                                 | Not at all as anticipated | As anticipated | More modern than anticipated | More traditional than anticipated | Total |
|-----------|-----------------------------------------------------------------------|---------------------------|----------------|------------------------------|----------------------------------|-------|
| 5(a)      | Expectation on the clam conservation activities in the area.          | 18%                       | 23%            | 53%                          | 6%                               | 100%  |
| 5(b)      | Expectation on the Bajau people.                                      | 0%                        | 35%            | 18%                          | 47%                              | 100%  |
| 5(c)      | Expectation on the authenticity of arts and crafts from giant clam products. | 0%                        | 41%            | 6%                           | 53%                              | 100%  |
| 5(d)      | Expectation on the tradition and cultural of local people.           | 0%                        | 38%            | 0%                           | 62%                              | 100%  |

Table 4 shows the perspectives of the respondents on Bajau ethnicity. These questions were answered along a 4-point Likert scale, from 1 (Not at all as anticipated) to 5 (More traditional than anticipated). Main points of the questions were expectation on the clam conservation, Bajau people, authenticity of arts and crafts from giant clam product and tradition, and cultural of local people. Majority of the respondents answered on more traditional than anticipated on question 5(b), 5(c) and 5(d), but not on the clam conservation efforts. Conservation efforts were viewed as more modern than anticipated. While, second highest point was on ‘as anticipated’ because the respondents themselves are Bajau people or local people that are adhere toward Bajau community. ‘Not at all as anticipated’ scored the lowest points shows that the respondents are aware on the traditional values of Bajau people in their community. This knowledge could be utilized to ensure the efficient and values of giant clam conservation in Sabah.

5. Discussion
The discussion is based on the objectives of this research, which is to (1) to determined and identify the traditional ecology knowledge (TEK) of the Bajau ethnicity on giant clam consumption; (2) to evaluate the challenges in giant clam traditional management based on Bajau ethnicity.
5.1 The Sharing of Traditional Conservational Practices

The TEK practice of Bajau people could be integrated into giant clam conservation in Sabah as an improvement toward the conservation and management toward the marine resources in Sabah.

The dependency of Bajau people on the maritime are important for giant clam conservation in Sabah. There are large portion of Bajau people that still rely on the sea because their skills are limited to the maritime activities [11][17]. Due to this, most of the Bajau community that occupy settlement in coastal areas and utilizing marine seasonal [11][17] have traditional knowledge that are formed through their interaction with their habitat. This shown that Bajau community are highly tied with the environment as the way of their life. Cultural and traditional knowledge of the Bajau people are highly valuable in managing marine resources as their cultures could preserves values on human-environment interaction and the necessity in protecting it, while gaining appropriate benefits from the nature. Belief system of Bajau people that shaped their practices of collecting and harvesting marine resources for their livelihood [18] makes them appropriate patrons to monitor the conservation area. The harvesting and collecting process of giant clam that are done in moderate and small scale by the Bajau people [18] have been integrated into one of the management zones by Sabah Parks as a mean of early effort on conserving and protecting the area of importance. Methods in collecting giant clams depends heavily on the location, size and distribution of giant clams, this also including the size of family. Location with high accessibility and high abundance of giant clams use simple methods in collecting like using hand and simple equipment [16]. This method is commonly practiced by Bajau housewives and fishermen with small boats [11][18]. they only harvest several large giant clams and it was limited because of their small boats and family sizes. Several giant clams were enough for large families and extra meats would be used for barter system or given to their neighbours and other family. This act was done as a sign of kindness [16] and to shaped positive relationship among the community. This also related to the beliefs of Bajau people on overharvesting the marine resources leads to the wrath of sea spirits and this, inviting environment disasters [16]. This kind of belief systems and its effect on practice and tradition on collecting giant clam are suitable with the management zone proposed by the Sabah Park as the Community managed zone are where non-destructive small scale and traditional fishing activities are allowed. This alone would ensure the supports from local people as their livelihood were included in the conservation effort.

One of the studied local practices that is involving giant clam and was adopted into giant clam conservation efforts are known as ‘clams garden’. These practices were recorded in Lucas & Copland (1988) known as ‘clams garden’ by the local people because of the aesthetic value provided by the giant clams and these were incorporated and supported by enforcement in the giant clam conservation in Solomon Island. Similar practice was found among local people in Semporna, Tun Mustapha Park and Pitas. These clams were collected by the housewives and kept them minimally for three years because of aesthetic purposes, and for food sources during lack of foods. Some of the household in Sabah kept giant clam for their aesthetic appearance and to attract tourists into their area. In some cases, collected giant clam were kept and cooked for important ceremonies such as wedding ceremonies. This practices actually helps in minimizing harvesting and collecting activities in the wild population. Conservation effort could be improved if enforcement provide supports [18] and equipment supplies in developing the practice to a nursery handled by the local people [3]. Giant clam in the wild population could be restock and protected until the population increase again [3]. This also helps in training and developing the livelihood of local people, while conserving giant clams. This was conducted in Tun Mustapha Park (TMP), Kudat and Semporna, Sabah by the Sabah Park. The conservation efforts include local people, mostly were Bajau people, into consuming and utilizing...
giant clam to increase their livelihood, and the resources were taken from nursery and restocking that are specialized for the local people. Enforcer allowed them to trades and consume giant clams, but it was illegal to be export and traded outside Malaysia and the act of trading and exporting giant clam outside Malaysia could be prosecuted and compound according to the Fisheries Act 1985. According to the manager that managed giant clam conservation of giant clam in Sabah, these conservation efforts help in educating the local people and publicizing public awareness on the conservation of giant clam In Pulau Gaya, local people offered services for the tourist in creating experiences by living like a local people for a day. The routine lives of local people and surrounded by natural environment become an additional point in attracting international tourists [18]. Pulau Gaya was known through the MERC and Gayana resort, in which they promoted giant clam conservation and conducting environment education for tourists and local people.

This information is significant because of its potential to integrate local and global knowledge, to connect traditional cultures and modern approaches and to relate biological and social aspects of the human experience to the environment [2]. Bajau TEK in this study encompasses various types of practices that could be integrated into modern conservation and taking heavily on the livelihood of Bajau people and their role in conservation of giant clam in Sabah.

5.2 Challenges in traditional management of Giant Clam based on Bajau ethnicity

Low population of giant clam drives the conservation and management effort in Sabah, but these efforts seemly inefficient. Before implementing Bajau TEK related to the giant clam conservation in Sabah, challenges regarding the implementation should be understood.

Research activities regarding to Bajau TEK should be conducted and documented. One of the main challenges in implementing Bajau TEK into giant clam conservation in Sabah are the lacking of research and documentation of the Bajau tradition [12]. Research and documentation TEK could help in deciding on which tradition and culture Bajau are complementing and appropriate with the giant clam conservation in the area. Choosing of appropriate Bajau TEK are important in protecting the population of giant clam in the wild, while improving the livelihood of local people through the utilization of the resources. However, different opinions, critics and recommendation studied documents and records are required to predict the risks or benefits as a result from the implementation [3][18]. This implementation shows the importance of participation of Bajau people as well. According to one of the respondents that are experienced in managing and conserving giant clam, these efforts should include local or indigenous community that act as a patron. Disregarding the rights of local community such as the Bajau people to utilize and consuming giant clam resources would cause the efforts to be inefficient [16]. Bajau people have the extensive knowledge in maritime affairs, including handling or utilizing the marine resources in the area [11-12][18]. One of the challenges in conducting conservation including the traditional management of giant clam are conforming the roles of Bajau people in the giant clam conservation effort. Their knowledge on giant clam should be recorded along with providing them training in managing giant clam resources. Practices such as keeping giant clam as food resources and for aesthetic value should be supported by the enforcement, and the practice and method in harvesting giant clams that are safe for the coral reef environment should be allowed. Enforcement should be assisting and training local people in managing and monitoring their environment from activities that degrading and destroying their habitat [3]. Therefore, with sufficient references and information of Bajau TEK, it is easier to considered several aspects of the TEK for giant clam conservation in Sabah. Through this, blueprints could be developed for this
implementation, conflicts between the conservation and community livelihood could be improved or solved.

Public awareness and environment education are important for local people, traders and tourists. This was highlighted and suggested heavily by the respondents. Public awareness can be achieved through dissemination of information using tools such as mass media or environment education. These tools help in informing the public on the status and importance of giant clam population in Sabah. Through public awareness, harvesting and trading of giant clam could be minimized into local trading by the Bajau or local people only, this emphasize the role of Bajau people and their TEK in utilizing while monitoring giant clam conservation. This was mentioned by one of the interviewees, that environment awareness and education have a large impact on the conservation efforts, just like the case of prohibition of consuming shark fin and protected turtle eggs in Sabah. According to the respondents, younger generation are the easiest targets because they can be trained and educated in the early age, while the older generation requires extensive explanation and persistent advice as they are more tied to the tradition rather than the young one. However, public awareness through mass media could bring negative effect on the giant clam conservation [3] in Sabah as it may cause giant clam to be commercialized in consumption industry, increasing the demands from consumers, even though it is illegal to be exports and trades. This case usually cause increase in illegal harvesting in the conservation area and illegal harvesting commonly conducted in a large scale, either by local people or fishermen, threatening the population of giant clam in the wild. Thus, environment education must be conduct in a way it can disseminate information on giant clam and reduce demands from consumers, while minimizing the demands from consumers.

6. Conclusion
This study helps in scientific documentation on the traditional ecology knowledge of Bajau people to reduce the gaps in management and conservation efforts of giant clams. Recorded and documented knowledge helps in planning management that involves the experiences of the community in handling the resources in the area and thus, helping in solving the threats and challenges faced in the conservation and management efforts [2][12]. However, further study should be conducted in identifying traditional ecology knowledge and traditional management of giant clams among other ethnicity in Sabah, investigating ecological conditions before and after harvests following temporary closures, and monitoring fishing catch during regular fishing activities and from harvesting events [2]. Suitable approaches in developing and integrating the cultures and tradition of the local people into tourism industry helps in providing ideal management and conservation efforts that reciprocal with increased of livelihood in Sabah, creating sustainable development in managing and utilizing natural resources in the park. Therefore, the integration of Bajau TEK with the modern conservation should be considered to avoid the tragedy of the commons on giant clam conservation in Sabah.

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