

Communication Gap of Heavy Metals Knowledge among Community in *Batu Payung*, Tawau and Its Impact on Food Safety, Security and Livelihood Sustainability

Diana Demiyah Mohd Hamdan¹, Laila Udin¹, Rohana Tair¹ & Mohd Hamdan Adnan².

¹Faculty of Science and Natural Resources, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia
(diana.demiyah@ums.edu.my, lailaudin2@gmail.com, rohana@ums.edu.my).

²Faculty of Arts, Humanities and Heritage, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia
(hamdanani@gmail.com)

ABSTRACT

This study investigates the knowledge level and communication gap regarding unsustainable harvesting and over consumption of *Meretix meretix* or locally known as *dalus*, a protein resource aqua life impact among the *Batu Payung* community in Tawau. It also studies the extent of indigenous knowledge with regards to consequences of heavy metal consumption and of the *dalus* conditions. *Dalus* spends most of its life in sediment acting as a sink for contaminants such as heavy metals. Filter feeders like *dalus* pose health risk to consumers when it accumulated excessive heavy metals out of the permissible limit from its living environment. Over consumptions of high concentration of heavy metals in seafood have shown to be very damaging to consumer health. Consequently, over consumption or over harvesting of *dalus* can endanger the aqua farmers' livelihood as well as its sustainability for future generation. Qualitative and quantitative study had been conducted by interviewing local communities living at *Batu Payung*, Tawau to assess the harvest and consumption pattern of *dalus* whether its practice is sustainable or damaging. Altogether 82 respondents were interviewed on January 2017 to evaluate the local community knowledge on heavy metal and food safety related to *dalus*.

Only 17 respondents knows about heavy metal contamination can occur in *dalus*. This study looks at seven components: (1) Consumer, (2) Heavy Metal Knowledge, (3) Communication, (4) Public Health, (5) Natural Resource, (6) Nutrition Value and (7) Local Diet. The study indicates a very low level of knowledge among the aqua communities of heavy metal content in *dalus* and its impact on food security and livelihood sustainability.

Keywords: Aqua communities, heavy metal, food security, sustainability, public health, *Meretix meretix*, environmental awareness

Introduction

Extreme climate conditions caused food shortage at terrestrial areas even in early human evolution. Human continue to survive by scavenging the coast for food resource such as clams. Gathering clams does not require special tools where man can use bare-hand to dig out clam and no special skill like swimming is required as man can gather clam during low tide (Thomas 2015). Regardless of gender and age all can be involved in search of this food source. Overexploitation of marine natural resources is not a new problem as several archaeological findings have shown that this had also happened repeatedly in the past (Thangavelu, et al 2011). One of the sign that marine natural resources becomes limited when the average harvested shell size became smaller in size (Ash et al 2013, Alvarez-Fernandez et al 2011).

Consequently, depletion of this food resource had forced human to move on to other productive places in search of food. However, the recovery process of these exhausted marine living things takes a very long time. Presently, only a few communities are living like nomads and the numbers of mouth the earth has to feed at one time is in billions as compared to nomadic lifestyle of our early ancestors. Therefore, the consumption habit of a human population is closely intertwined with food security and livelihood sustainability. Learning from past mistakes and managing natural resources well can only be done by effectively passing down indigenous knowledge and ensuring no communication gaps or breakdowns occurs. Generating new information on the subject of food security is essential as climatic changes become faster due to numerous environmental factors.

The Asiatic hard clam or known locally as *dalus* is one of the available selections in gourmet seafood menu which is offered for seafood lover visiting Sabah. Supplies of *dalus* come from coastlines which connected to different seas in Sabah. Distribution of *dalus* family located in Sabah state, *Meretix sp.* has been previously recorded at the beach of Bongawan, Lok Kawi, Kudat (Mohd Ali et al 2010, Sharif et al 2016). Not just an important source of protein, *dalus* also provide livelihood to aqua community in coastal areas for its commercial value (Yeh, et al 2017, Hamli, et al 2012).

Apart as a food source, *Meretix meretix* is suggested as good biological indicator for monitoring heavy metal pollution in coastal areas of many parts of the world (Alyahya, et al 2011, Wang et al 2009). Different growth stage of *Meretix meretix* shell size that had been collected on the same harvest season also shows significantly different concentration of heavy metals in edible tissues (Khanh et al 2010).

The importance of protein diet has been exposed to children as early as primary schools in Malaysia education syllabus or Malaysia Food Pyramid (Tee 2011). However, some heavy metals or also known as trace element which is an important part of diet requirement for living organisms like plants and animals has not been introduced much on primary and secondary school education in developing countries (Ruzita, et al 2007, Ahmad, et al 2016).

Heavy metals can be divided into two categories: essential heavy metals and non-essential heavy metals. Essential heavy metals are required in a certain amount for biological activities of living organism. Therefore, essential heavy metals are a very important nutrient for a healthy life. Shortage or excess availability of essential heavy metals in human body can have deleterious effect on health. On the other hand, non-essential heavy metals are not known to have any functioning role in human body systems in any researches that have been conducted. Heavy metals entered the body through consumption or transferred via food chain (Croisetiere et al 2006). Like *dalus* which consumed heavy metals from its food, *dalus consumer* will also absorb heavy metals from the *dalus* directly. Thus, it is essential that *dalus* sold or consumed do not contain heavy metals beyond the prescribed safety limit.

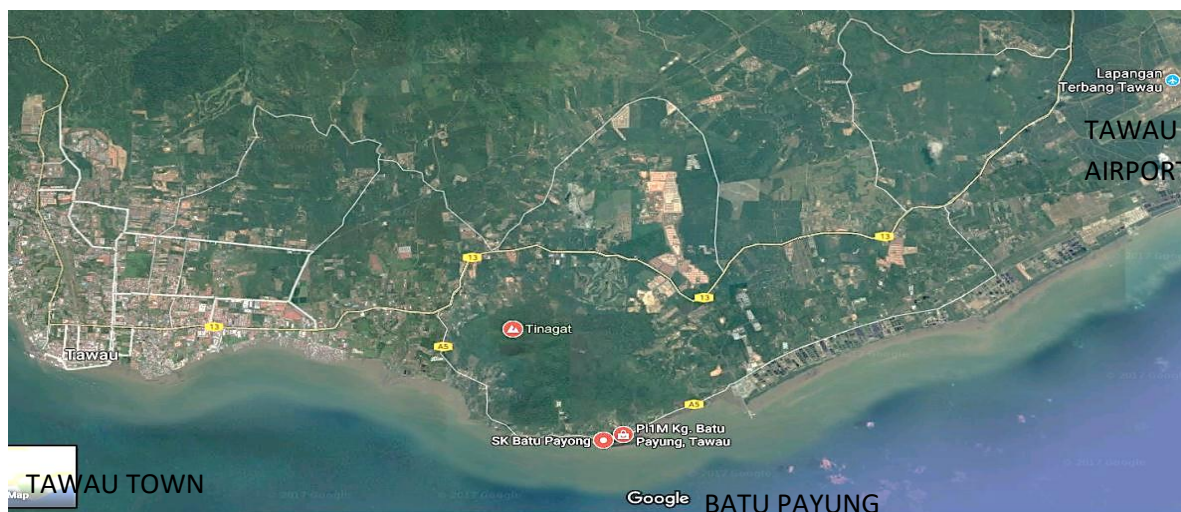


Figure 1. Batu Payung area is situated near the coastline which is between Tawau Town and Tawau Airport (Google Map 2017).

This study was conducted along the coast of *Batu Payung* coast in Tawau district of Sabah (Fig.1). *Batu Payung* is located about 25 kilometers away from the east of Tawau town. Study site of *Batu Payung* beach coast is at latitude 4°14'08.5"N and longitude 118°01'19.2"E which is rich with marine natural resource like *Meretix meretix* or named *dalus* by the local community (Fig. 2a). Wild *dalus* on this coast can be easily accessed by the public. *Dalus* are collected during low tide by using hand to dig out from the sand (Fig. 2b).

No sophisticated tools are required to harvest this benthic organism. Therefore anyone can harvest *dalus* on this beach for their own consumption or livelihood. Apart from fish, prawn, and crab, *dalus* is also an important protein source for Tawau communities.



Figure 2 (a) Wild *dalus* on the beach of *Batu Payung*, Tawau (b) Study site of *Batu Payung* beach during low tide where on the far background there are locals searching for *dalus*.

Study Objectives and Methodology

The objective of this study is to determine the extent of indigenous or local knowledge impact with regard to the effect of heavy metal on the respondents' health when harvesting and consuming aqua life in the like of *Meretix meretix* or locally known as *dalus*. It also studies the level of diffusion of this indigenous knowledge to the next generation or incoming residents.

This study also attempts to discover the extent of relevant agencies in trying to disseminate information about the effect of heavy metal upon consumers and the residents of *Batu Payung*. It attempts to study the effectiveness of such efforts.

The study further enquires on the feasibility of enhancing *Batu Payung* as a tourist attraction and the promotional efforts that have been implemented to make it a success.

For the purpose of this study the diffusion of innovation theory is used. Diffusion is defined as the process by which innovation or new ideas is communicated using selected media overtime among members of the target public or social system. The key elements of the diffusion of innovation theory are attributes of innovations and their rate of adoption;

adopter categories; change agents; stages in the innovation-decision making process and the case study.

The case study and the target public or respondents for this research is the residents of *Batu Payung* and the consuming public or visitors who frequented the location for recreation or buying seafood like the *dalus*. This site was selected because the residents of *Batu Payung* are generally fishermen and small time farmers. It is also the location where *dalus* is presently in great abundance and nearly all its residents are involved in gathering *dalus* at one time or another. Further, this area has the potential to be polluted by heavy metals and the study is on the knowledge of residents and consumers on the impact of heavy metals on *dalus* and its effects on those consuming it.

For the purpose of this study a simple random sample method is chosen where each member of the selected public has an equal probability of being a respondent. A questionnaire was formulated and tested to ensure its clarity and meeting the desired objectives.

Questionnaire

The study questionnaire consists of three sections divided into Section A, Section B and Section C with a total of 36 questions (Q1~Q36). The questionnaire was prepared in two languages which is English and Malay language. Section A consists a set of questions to gather information of socio-demographic and socioeconomics of random individuals that was near the location of study site during sampling (Fig. 2b). Socio-demographic questions established respondents' gender (Q1), age (Q2), marital status (Q3), body weight (Q4), resident location (Q5), ethnic (Q6), and religion (Q7). While socioeconomics question established respondents' education level (Q8), occupation (Q9), monthly income (Q10) and health status (Q11, Q12).

Section B of the questionnaire consists of questions (Q12-Q27) to assess the harvest and consumption frequency of *dalus* of the respondents. Consumer behaviour and their eating habits on *dalus* were also analysed.

Section C was designed to assess the local community environmental awareness and knowledge on heavy metals in *dalus*. A set of 9 questions (Q28-Q36) on a 5-point Likert scale (1) "totally disagree", (2) "disagree", (3) "not sure", (4) "agree" and (5) "totally agree" for section C had been analysed.

Questionnaires were distributed on January 2017 to *dalus* collectors and sellers, *Batu Payung* residents and Tawau communities to 82 respondents. It is noted that the *dalus*

collectors and sellers were generally from *Batu Payung* and the Tawau communities were usually the buyers and consumers of the *dalus*.

Pearson Correlation Coefficient

In this study, the application of Pearson Correlation Test was used to show which variables have strong relationship for further analysis. This technique was applied in this study to ensure the relationship among the entire parameters and to identify which show the strongest relationship where two variables whose relationship ranges from -1 to 1 were measured. The correlation coefficients of a value >0.75 are considered 'strong', correlations in the range of 0.74-0.5 are considered 'moderate' and those in range of 0.49-0.30 are considered 'weak' correlation. For this study, all the correlation value was taken into account because its shows the characteristics of the variables contribution from questionnaire. Since this study is related to a small group of community so the simple relationship is much meaningful to explain. The correlations analysis was done by the SPSS software.

Principle Component Analysis

Principle component analysis (PCA) refers to a method of data analysis for building linear multivariate models of complex data set. One of the significant goals of PCA is to eliminate the principle components associated with interference, thereby reducing the dimensionality of complex problems and minimizing the effects of measurement error. However, the originality of data is important for measurement. This analysis is based on Eigen value criteria which called "loadings" whereby a value >1 is considered significant. The profile of factor loadings and specific indicative questions were used to deduce the factors obtained and to identify the variable had been study (Gemperline, 2006). In this study, the PCA performed after varimax rotation of the normalized data contained 36 questions (Q1~Q36) for 82 respondents.

Research Findings and Discussion

Batu Payung Socio-demographic and Socioeconomic Background

Table 1: Respondents ethnicities and religions

	Bugis	Malay	Bajau	Kadazan	Murut	Chinese
Muslim	33	17	15	15	0	0
Christian	0	0	0	0	1	0
Buddhist	0	0	0	0	0	1

Batu Payung is not only rich with natural marine resource but rich with culture as it consists of diverse ethnics (Table 1). Most of the *Batu Payung* residents are Muslims

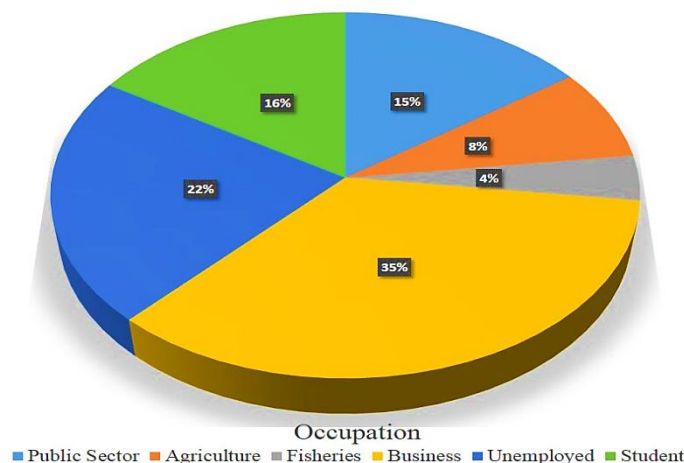
comprising of Bugis, Malay/Tidung and Bajau. The largest ethnic groups in Sabah, the Dusun-Kadazan respondents living near *Batu Payung* answering the questionnaire are all Muslim too. The number of respondents according to gender (man and woman) and marital status (married and single) for this survey are almost equal number to each other (Table 2).

Majority of the respondent occupation were related to the business sector followed by the public sector (Fig. 3). Some of the respondents were students enrolling in secondary schools and all are young adults. The youngest age group in this survey which is between 18 to 29 years old had at least received formal education of primary school compared to the older age group where a very small number did not managed to receive early education at all during their childhood (Table 2). In *Batu Payung* area, a primary school name *Sekolah Kebangsaan Batu Payung* has been established since 1962 (Fig. 1). In recent years, early education is already affordable and almost reachable for every child which is an improvement of the past for this coastal area. In line with Malaysia's commitment to the Dakar Framework for Action, primary education is free and compulsory for all. Finding of respondents educational background reflect equality in gender whereas women living at *Batu Payung* has at least received early education similar to men (Table 2) where nearly all respondents are Muslims (Table 1).

Table 2: Respondents education level & monthly income according to age and gender

Age (years old)	Man	Woman	Man	Woman	Man	Woman	Man	Woman
Educational Level	No formal Schooling		Primary School		Secondary School		Tertiary Institution	
18-29	0	0	3	1	5	5	11	12
30-39	1	1	1	1	4	8	6	1
40-49	0	0	0	0	5	4	0	1
50-59	1	1	2	0	3	3	1	1
TOTAL (%)	5		10		45		40	
Monthly Income	<RM500		RM500-RM1000		RM1000-RM3000		>RM3000	
18-29	11	12	0	4	7	2	1	0
30-39	0	6	1	1	9	4	2	0
40-49	1	2	1	0	3	2	0	1
50-59	1	4	2	0	3	1	1	0
TOTAL (%)	45		11		38		6	

Figure 3: Respondents according to their main occupations.



There are only seven participants working in the agriculture sectors and three participants working as fisherman. A quarter of the respondent is not employed which includes housewife. Although 22% of the respondents is not employed, only two did not received early education, one went to primary school, the rest 15% of the respondents not in employment did complete their secondary education.

Nearly all of the participants working in the public sector have at least secondary school education earning minimum wage of RM1000 a month (Table 2). Half of the respondents' incomes are below the poverty line of RM500; some of them are students or unemployed.

Just about a decade ago in Tawau district, there were children who could not further or complete their primary or secondary schooling due to socio-economic limitations as they had to work to supplement their family household income (Aziz et al 2013). Due to the interruption of furthering their early education, these children who had become workers at a tender age when they grew up faced great difficulties to improve their life. They met limitations of work opportunities offering them better wages. Thereby education level does influence future working prospect and improvement of livelihood. Moreover, economic developments which can create jobs and opportunities are strongly influence by the availability of skill and education of human resources in that area (Abu et al 2014).

The monthly income of nearly all fishermen or aqua farmers who participated in this survey was below the poverty line or below MYR800 per household income. Also, their livelihood stability is closely connected with the marine ecosystem. On the other hand, respondents engaging in land agriculture received better income compare to fisherman at *Batu Payung* area. Nearly all working in the agriculture sector have at least enrolled in

secondary school. One of the main agriculture developments in present Tawau is the oil palm plantations which offer better income as compare to other sectors such as fisheries.

Income from Aquatic Products/Harvest

The Asiatic hard clams have economic value where in some part of the world it is even exported and heavily exploited (Yeh et al 2017). In Sarawak, *Meretix lyrata* or *dalus* can sell between RM2 to RM20 per kilogram (Hamli et al 2015). During this study period at *Batu Payung*, *Meretix meretix* was sold between RM4 to RM6 per kilogram according to sizes. The community at Salut near Kota Kinabalu which is blessed with marine resource likes the mud clam or *lokan* (*Polymesoda sp.*) is very enterprising by setting up makeshift stalls along the Sulaman Road (Mohd Hamdan et al 2016). Their small enterprises started by offering raw and grilled *lokan* to customers. Initially there were only one or two stalls. Now due to increasing popularity, there are at least more than 20 stalls in the same business lining up next to each other and new stalls are still building up. Moreover, the price of *lokan* at Salut area has been steadily increasing due to the high demand for this local delicacy.

Customers are not only locals but it has also become a popular stop for tourists to taste local *lokan* delicacy and enjoy coconut drink. Frequent customers of Salut eateries offering grilled *lokan* comes from different sociocultural background. These also apply to the shop owners. Correspondingly, *dalus* consumers at *Batu Payung* comes not only from different socioeconomic background but various sociocultural background (Table 1) who all have seafood diet consisting of *dalus* for at least monthly (Fig. 5c).

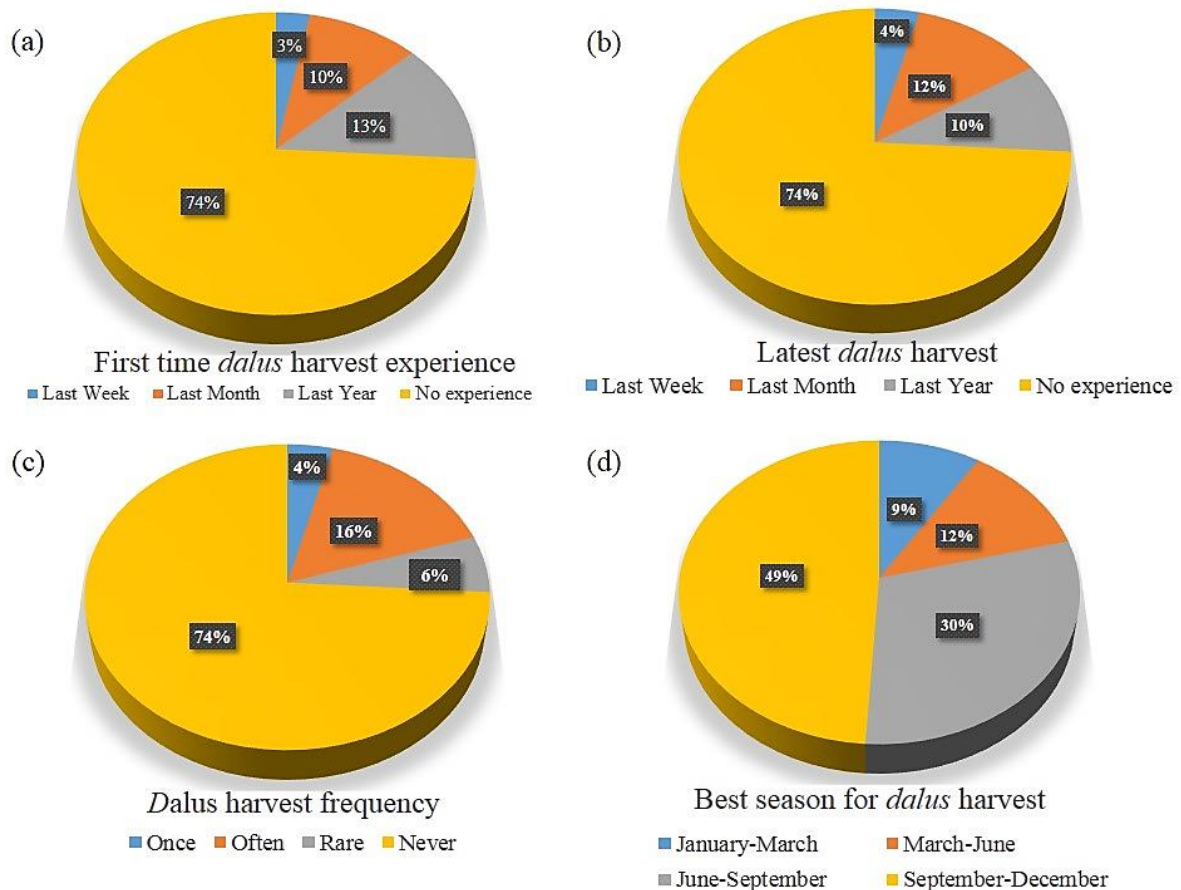


Figure 4 (a) Pie charts show respondents percentage of when they had their first time experience of collecting *dalus* in their lifetime. (b) The last time respondents went and harvest *dalus* from their wild habitat. (c) How often does respondent goes to collect *dalus*. (d) Respondents preference season of harvesting *dalus*. All percentages are calculated for total 82 individual responses (Q20-Q23).

Natural resource on the coast of *Batu Payung* like *dalus* is available for public to harvest all year round. Nevertheless, only a quarter from the total respondents has experience on harvesting *dalus* at *Batu Payung*, Tawau (Fig. 4a). Results from three questions in the section B of this survey are consistent where 74% of the respondents never gather wild *dalus* in their whole life (Fig. 4a, 4b, 4c), although all are regular *dalus* consumers (Fig. 5c). Not all of the *dalus* gatherers prefer seafood as their main source of protein; some prefer poultry meat (Fig. 5a).

The price of *dalus* is considered very cheap at *Batu Payung* where many prefer to buy from the local market rather than going to the beach to gather *dalus* themselves. Regardless of *dalus* cheap price at the study area, majority of respondents gathering wild *dalus* claimed to have an average monthly income exceeding RM1000. Majority of these *dalus* gatherers are below 40 years old and working in different sectors (Table 2). More than half of the

respondents who have experience harvesting *dalus* are actually beginners or first timers. Regular *dalus* gatherers frequented *Batu Payung* to collect *dalus* either fortnightly or once a month (Fig. 4b, 4c).

Batu Payung is also a known popular beach recreation site close to Tawau for the local community apart it being the *Meretix lyrata* or *dalus* natural population location. Thus, *Batu Payung* coast not only provide food source but recreational shell-gathering species.

Batu Payung coast is also a suitable place to be developed like the well-known Salut grilled *lokan* eateries for economic development to provide more job opportunities and stable livelihood for residents in that area. Regular customers spreading good reviews about Salut eateries along the Sulaman Road had been the main effective communication to make *lokan* well-known as affordable local delicacies to enjoy for all sociocultural and socioeconomic background (Mohd Hamdan, et al 2016).

Many respondents in the business sectors indicates (Table 2) that they are human resources who can help increase *Batu Payung* economic development by using the natural resource like the bivalve *dalus* (Abu, et al 2014). Natural environment of *Batu Payung* itself attracts many visitors from Tawau district as it is a popular recreational destination and not just for the recreational shell-gathering. Furthermore, majority of the respondents admitted that they buy *dalus* from harvesters and suppliers rather than directly harvesting *dalus* themselves (Fig. 4c).

Three of the respondents who work as fisherman in this survey, only one are a regular gatherer of *dalus* who resides in *Batu Payung* and earn more income than the other two. The youngest fisherman in this survey who lives in *Batu Payung* is a newcomer in gathering *dalus* and his first experience was December 2016. After the initial experience, he collected *dalus* often at *Batu Payung* indicates that there are high demand of *dalus* supply and provide sustainable livelihood. The only woman who works in the fisheries sectors lives in *Kampung Pasir Putih* and is not a shell gatherer species. If *dalus* can be develop as a tourism product like the grilled *lokan* at Salut, the increasing and continuous demand of *dalus* can help increase the livelihood or income of the local fisherman. It is suggested that the local authority and the Department of Fishery plus the tourism authority should look into this so that a systematic approach can be taken to enhance the income of this people as well as turning it into a tourist attraction.

Respondents collecting *dalus* for their income are in agreement that the best season to harvest *dalus* at *Batu Payung* is at the end of the year around September to December. Most of the regular recreational *dalus* gatherers are also in agreement that the best season

to harvest *dalus* at *Batu Payung* is at the end of the year particularly September to December (Fig. 4d). Most of the respondents who answered early of the year (January-June) are the best season to harvest never went there to gather *dalus*. From experiences and local knowledge, regular *dalus* gatherers are aware when the best *dalus* harvest season at *Batu Payung* is. From this it can be concluded that the amount availability of *dalus* harvest is seasonal.

Previous findings have shown that certain species of shellfish availability not only differ on total harvested amount but significantly in average size shells gathered according to which month of the year (Lasiak 1992). Clearly, proper management of this natural resource must also be taken in account by understanding the biological clock of this species in that specific area to avoid overexploitation which can affect not only *dalus* but other consumers connected through the complex food web belonging to the same ecosystem (Bhadja et al 2014, Mannino and Thomas 2002). Not only food security for human who is the top predator of the food web will be affected but also livelihood sustainability is also involved (Thangavelu, et al 2011, Ruis et al 2006). Also, the sustainability of the aquatic life including *dalus* need to be better protected. Thus, all relevant authorities must ensure that both the aquatic harvesters and the consumers are provided with the current knowledge enabling them to harvest *dalus* without endangering its sustainability and ensuring the safety of all consuming it. Nearly all respondents propose that the appropriate authorities should published leaflets or uploaded materials pertaining to it plus using radio and television to ensure a wider coverage of the subject.

***Dalus* Consumption Habits & Food Security**

Tawau district coast is very rich with marine resource and high density of biodiversity. Not surprisingly more than half of the respondents who visited *Batu Payung* coast prefer seafood for their protein diet (Fig. 5a) which conformed to similar question in section C of the questionnaire (Figure 6). According to visual *dalus* shell size, majority of the respondents prefer large size and eat *dalus* at least once or twice a month (Fig. 5b, 5c).

According to this study in average a person will consume 10 pieces of *dalus* whole tissue for each meal. Although *dalus* is not the staple food of the locals of *Batu Payung*, it still left a mark as one of the local diet as all household have *dalus* dish at least once a month.

Also, according to this study, the local people tend to avoid consuming *dalus* frequently as they are very alert that *dalus* can be contaminated with pollutants, although they are not sure or totally ignorant to the source of this contamination (Figure 6, 7a).

The study would conclude that past events must have occurred creating awareness to make the local community cautious not to consume this hard clam species frequently. According to respondents, local stories have transform into local knowledge by orally passing it down to the younger generations or other related people as a foundation that help to curb overconsumption of *dalus* at study site. Moreover, there are also plenty of other selections of seafood resources cheaply available for seafood lovers in this local community (Yamazaki & Oda 2009).

Further, this study found that there is no local knowledge at *Batu Payung* on bigger shell size of *dalus* is safer to eat than the smaller ones (Fig. 6). None of the respondents claimed to have knowledge about it. They are happy to know this fact and hope that such knowledge are made available to them so that they can avoid harvesting the small *dalus* not only it is less safer than the big ones but also it can contribute to sustaining their livelihood as aqua harvesters as well as safeness to their consumption. Also, they said that they would hope for more information on this fact from the relevant bodies including the mass media and the social media.

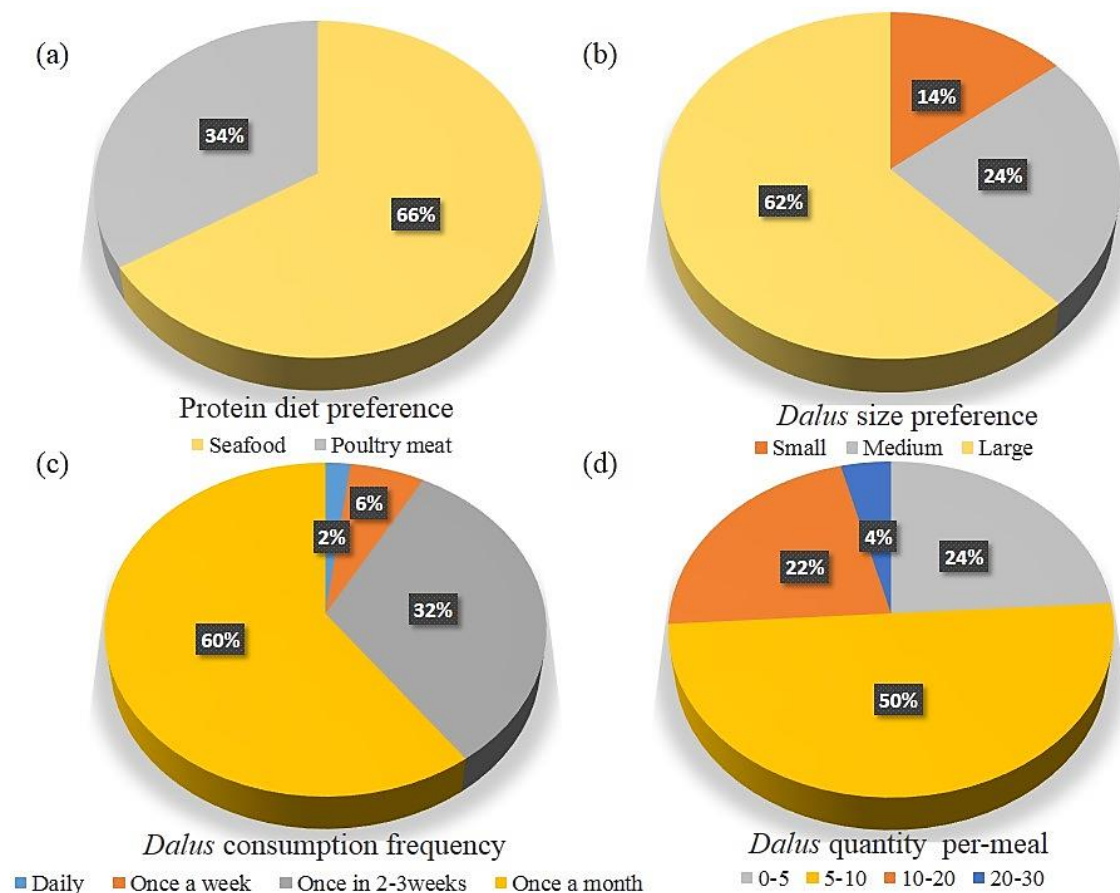


Figure 5 Pie charts show the response percentage from 82 respondent of *Batu Payung* from Section B (Q14, Q17-19) of distributed questionnaire (a) Which protein resource is

more preferred by the individual (b) Which size of *dalus* is most preferred (c) Consumption frequency of *Dalus* (d) How many *dalus* is consume for each meal.

All living things will grow up and naturally take part in reproduction as a means for the species to prevent extinction. Reproduction occurs when organisms have grown large and mature. Thus to ensure *dalus* at *Batu Payung* numbers did not decline rapidly, the preference of *dalus* size by the local people play an important role to ensure *dalus* are not prevented to mature and reproduce. Fortunately, many *Batu Payung* consumers prefer large size *dalus*. This makes it possible for some *dalus* to continue the cycle of life by producing progenies (Fig. 5b). In due course the offspring will be safely allowed to mature and reproduce before there are gathered.

However, marketing strategies at Salut grilled *lokan* enterprises; frequent customers prefer smaller size rather than larger size due to cheaper prices (Mohd Hamdan, et al 2016). Also, Salut eateries main customers are students with tight living budget from nearby tertiary institution. Consequently in the long run might impact the survival of *lokan* in nearby areas. Countries like Australia, Canada and United States of America had introduced regulations on season, minimum size and quantity limits of shellfish that can be harvested from the natural population to manage these marine resources from overexploitation especially for recreational shellfish activities. Although resources of *dalus* seems adequate for the local community of *Batu Payung*, early intervention to avoid the loss of food resources and livelihood for future generations is required by introducing regulations and conservation activities (Iwaoka & Okayama 2009). During sampling, researchers observed that a few raw *dalus* seller at the local market of *Batu Payung* had already use business strategy of selling different prices of *dalus* sorted according to size.

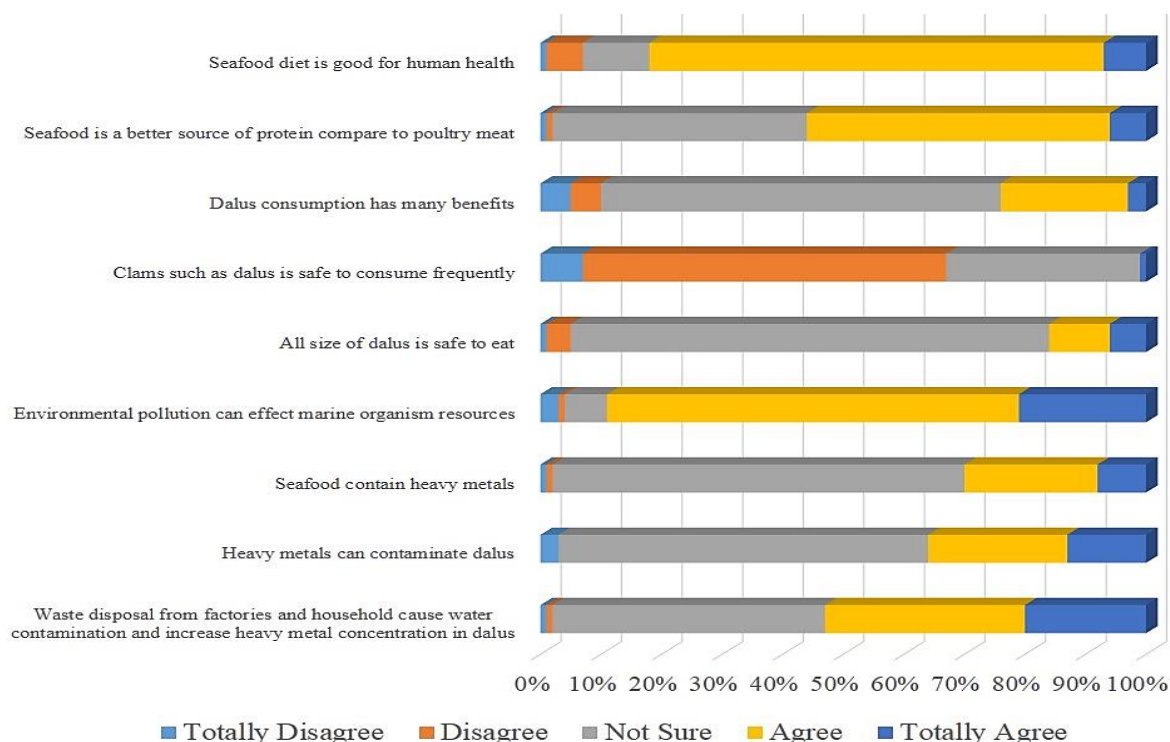


Figure 6 Data summary of Section C from the questionnaire which had 9 questions to access local community of *Batu Payung* awareness on seafood and heavy metal pollution according to percentage of Lickert Scale.

Dalus Nutritional Value and Heavy Metal Awareness

Local communities of *Batu Payung*, Tawau have strong awareness in regards of pollution can affect the environment and natural resources (Fig 6). However, it is clearly certain that even there is environmental awareness; the basic source of pollution like heavy metal is not clearly understood. The term 'heavy metal' or in Malay language '*logam berat*' is not well understood by the multi-ethnics of *Batu Payung* local community (Table 1).

An essential heavy metal or trace element is needed in trace quantity of all living things to live well. Therefore some type of heavy metal is also an essential micronutrient for maintaining good health. Heavy metal naturally exist in the environment, merely human activities has accelerated the increase of heavy metals in the environment. Heavy metal become a pollution when bioavailability amount have exceeded than normal in the environment and pose health risk to living things through bio magnifications (Croisetiere, et al 2006).

Human is also part of the food web as consumers through the food that we eat will ensure whether it become a supplement or poison for our body. If the foods have high concentration of heavy metals then there is health risk. Likewise, the level of concentration of heavy metals in any terrestrial or marine environment will determine whether the environment is clean or polluted by heavy metal (Richir & Gobert 2016).

This study found that by local knowledge, respondents know that *dalus* is not safe to be consumed frequently (Fig. 6). However, the only basic information that they understand is one of the cause might be due to water pollution. They did not have the knowledge that bioaccumulation of heavy metal in *dalus* from the contaminated environment can result health risk by overconsumption of *dalus*. Terminology of '*logam berat*' must be clearly defined in nutrition guideline and the education system for better understanding how heavy metal is beneficial and how can it can be one of the source of pollution.

Seafood diet is a part of the Malaysia Food Pyramid in the same trophic cascade as meat widely promoted as a good healthy protein resource (Tee 2011). Many campaign and advertisement from The Ministry of Health and private sectors to convey this information has proven successful as it has even reached to rural areas like *Batu Payung*, Tawau (Fig. 6). Information of seafood is rich in zinc and iron is included in the 3rd level of the Malaysia Food Pyramid. Despite seafood has been promoted as good for healthy diet in terms of having other additional nutritional value than a protein source, the public awareness level is low.

This study revealed that the communities of *Batu Payung* have very low knowledge of heavy metals like zinc and iron are essential micronutrients for good health (Fig. 7c). *Batu Payung* community did not realize that *dalus* consumption has many benefits apart as a protein resource. Hard clam such as *dalus* do not only provide protein resource to *Batu Payung* local communities. Hard clam is also rich in fundamental micronutrients such as iron and zinc (Idris, et al 2017). Heavy metal like iron and zinc is an important maternal nutrition and early human development (Roohani et al 2013).

Pregnant mothers from low socioeconomics background understand that nutritious food is most important during pregnancy. However, they have low knowledge on which food can provide iron resource for their body needs (Daba et al 2013). Iron is important for haemoglobin formation and oxygen transport (Abbaspour et al 2014). Deficiency of iron is usually associated to anemia. Due to socioeconomics background, Malaysia students living in rural areas are significantly affected by anemia compared to students living in the city. After knowledge has been passed down to students involved in a trial study, significant improvement has been shown in level of awareness and attitude (Yusoff, et al 2013).

Levels of education and monthly income usually have positive relation with nutrition knowledge especially in rural areas similarly observed as the case of *Batu Payung* (Table 2). Public understanding and awareness of heavy metal among the community at study area can be developing through nutrition education programs conducted by school, workplace,

health centres and local council (Gibson & Ferguson 1998). Local harvest like *dalus* should be used as an example for food resource because it is much cheaper and accessible to the local community where many monthly earnings are below the poverty line following UNESCO education for sustainable development (ESD) (Ma et al 2008). *M. meretix* not only provides nutritional value as it has also many medicinal properties such as anticancer properties (Sugesh, et al 2014).

Main concern that might contaminate *dalus* in the following order is oil spill, fertilizer and heavy metal when given these three selections to choose on from the survey (Fig. 7b). Despite the fact that almost all of the respondents are aware that *dalus* can be contaminated by environmental pollution (Fig 7a), less than a quarter of the total numbers of respondents know that *dalus* contain heavy metal (Fig 7c). Out of 17 respondents who are aware that *dalus* contain heavy metal, only 12 respondents chose heavy metal, and the rest is more concern on oil spill as source that can contaminate dalus.

Interestingly unknown to some of the respondents, the by-product of oil spill and fertilizer are also actually link to heavy metal. The main contributors of heavy metal contamination in the environment are oil spill and fertilizer (Mustafa et al 2015, Atafar et al 2010). The level of heavy metal knowledge of *Batu Payung* Tawau community is considered low. A study done closer to Kota Kinabalu where education level and socioeconomics of the respondents is much higher than *Batu Payung* community background had moderate awareness of heavy metal contamination (Mohd Hamdan et al 2016). In consideration of the education and socioeconomic background of the community must also be taken account of the best strategies to increase the level of heavy metal awareness.

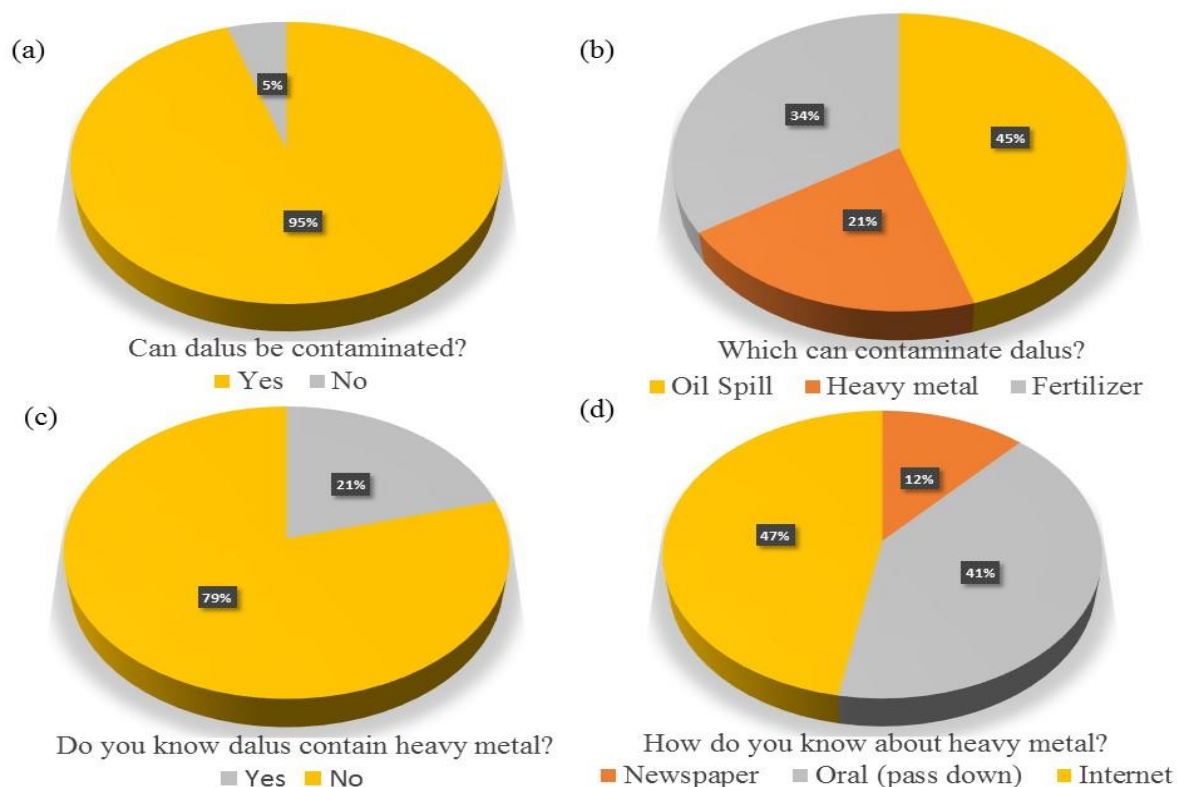


Figure 7 (a) Almost all of the respondents agree that *dalus* can be contaminated. (b) The main source of contamination that respondents perceived (c) Percentage of respondents that know *dalus* contain heavy metal (d) The source where respondent gain knowledge about heavy metal.

All percentage are calculated for total 82 individual response (Q24-Q27) except for (d) answered by only 17 individual who had answered question (c) yes.

This study revealed that the Internet provides 47% of the respondents with knowledge of heavy metal hazards and followed with oral communication as admitted by 41% of the respondents. Only 12% claimed that their knowledge about the danger of heavy metal in food came from newspapers. See Figure 7(d).

Thus, we can conclude that local knowledge and communication technologies by social media or internet seems to be one of the effective method for deepening the understanding of *Batu Payung* community the good and bad of heavy metals (Fig 7d). Surprisingly, majority of the respondents who have knowledge that *dalus* contain heavy metal does not have any experience harvesting *dalus* at Batu Payung. Only three of the *dalus* gatherer knew that *dalus* contain heavy metal. For conservation of this species to be successful, community-based activity programs need to be promoted in raising heavy metal awareness among *dalus* gatherers and all sectors of the society for sustainable development of the coast areas.

Clearly, oral tradition must not be sideline even though indigenous knowledge is rarely written down and are passed down orally by the interaction of shell gatherers like the best <http://jkob.cseap.edu.my/index.php/journal/full/edisi-khas-3-1.pdf>

season to harvest *dalus* and moderate consumption of *dalus* (Fig. 4d, 5c, 6). Indigenous knowledge provides valuable resource of information for the environment and public health (Warren & Rajasekaran: 1993). This study recommends that where possible indigenous knowledge should not only be studied but also be written down or transcribe. Further, its efficacy should be verified and if possible be improved in accordance to latest knowledge and technology.

Pearson Correlation Coefficient & Principle Component Analysis

From this study, the Pearson correlation coefficient was found in range of 0.22 to 0.969 at significant level more than 95% (<0.05) (Supplementary Table 1). Seven components were extracted from PCA (varimax rotation) with the total cumulative loading factor of variance (%) of 82.121% was described. The first from seven component elucidated consumer, second; heavy metals knowledge, third; communication, fourth; public health, fifth; natural resources, sixth; nutrition value, seven: local diet (Table 3).

The component of consumer shows the initial eigenvalue is 3.768 and the loading factor of variance is 16.196%. This component shows very high loading factor indicated the importance of selected respondents who can be categorized as a seafood lover which is supported by the correlation coefficient with very strong relationship between Q20, Q21 and Q22 (Fig. 4); $0.870 < r < 0.969$ ($p < 0.01$), respectively. Three important questions had contributed on this component.

The second component shows the initial eigenvalue is 2.935 and the loading factors of variance are 14.597% accounted for heavy metals awareness. The correlation coefficient consists of Q33, Q34, Q35 and Q36 shows strong relationship; $0.303 < r < 0.609$ ($P < 0.01$). The third component revealed communication with the initial eigenvalue is 2.241 and the loading factors of variance is 11.992% which consist of Q26 and Q27 (Fig. 7) ($r = 0.907$, $p < 0.01$). The fourth component shows the initial eigenvalue is 1.775 and the loading factors of variance is 11.683 % for Q15 and 16 which is accounted for public health and the fifth components shows the initial eigenvalue is 1.552 and the loading factors of variance is 10.766 % for Q13, Q14 and Q19 which elucidated on natural resources of *dalus* in environment, respectively. Next, the nutrition value shows the initial eigenvalue is 1.416 and the loading factors of variance are 9.148 % for Q28 and Q30. Lastly, the consumer local diet shows the initial eigenvalue is 1.094 and the loading factors of variance is 7.739 % for Q18 and Q25, respectively. The most significant variable from the Principle Component Analysis is the third component, communication which sits in the middle of consumers and public health.

According to Hudcova (2014), knowledge sharing and knowledge transfer is very important for making awareness to community. It is becoming the critical parts when involving facilities equipment and improving the process to transfer the right knowledge making the community ready for usage and application of the knowledge. Additionally, Gamble & Blackwell (2001) agree that knowledge is effectively transferred through interaction. So, interaction between organization and community to transfer knowledge and awareness were the most important value in this study. The knowledge transfer by communication interaction from organization to community in *Batu Payung* village can focus on public health, natural resources for sustainability, nutrition value of seafood would give villagers knowledge about the safety of heavy metals contamination in seafood especially *dalus*. Moreover, the strategy of communication about heavy metals or other pollutant must be developed and the applications be applied to community for two way interactions.

Table 4: Principle Component Analysis from 36 Questions and 82 respondents

Questions	Components						
	Consumer	Heavy Metals Knowledge	Communication	Public Health	Natural Resources	Nutrition Value	Local Diet
Q22	.970						
Q20	.962						
Q21	.935						
Q34		.821					
Q36		.780					
Q33		.739					
Q35		.713					
Q26			.948				
Q27			.938				
Q16				.974			
Q15				.972			
Q14					.859		
Q13					.762		
Q19					.709		
Q30						.884	
Q28						.820	
Q25							.853
Q18							.732
Total Initial eigenvalue	3.768	2.935	2.241	1.775	1.552	1.416	1.094
Loading (% of variance)	16.196	14.597	11.992	11.683	10.766	9.148	7.739
Cumulative loading (%)	16.196	30.793	42.785	54.468	65.234	74.382	82.121

Conclusion & Recommendations

This study revealed that the level of heavy metal awareness as to whether it is good or bad is low at *Batu Payung* as well as the other residents of Tawau district. This is due to the respondents' low education, poor socioeconomic background, lack of relevant facilities and opportunities. By enhancing the relevant facilities and opportunities as well as communication channels for acquiring the needed information it is believed that their educational achievements and socioeconomic levels can be much improved.

It is also recommended that the various relevant agencies like the Local Authority, Fishery Department and Health Department be more communicative with the *Batu Payung* residents to ensure that they have the current knowledge to improve their livelihood and wellbeing. A majority of the respondents claimed that their relationships with their related agencies are almost none. Hence, it imperative for these related agencies to have more communication with them, especially through interpersonal means or face-to-face as a majority of the respondents only have secondary education and 5% of them have no formal education at all. This is especially so when the subjects are complex and subject to many interpretations or that any third party can exploit the information for their own ends.

However, 40% of the respondents have tertiary education and it is suspected that they prefer or more trust data from the Internet as oppose to other forms of media channels. Actually, 47% of the respondents in the study said they got to know about heavy metal issues from the Internet. Thus, it is recommended that the relevant agencies should always update their homepage and to ensure that it is user friendly as well as containing current and appropriate information.

It is also recommended that the Education Department improve their facilities so that children in the concerned areas can improve their level of studies. In this study 60% of the respondents are just having their secondary education and below. In fact, 5% of them have no formal schooling. Many studies have proven that with better education citizens can improve their standard of living and be competitive and adaptive where ever they are, in rural or urban environments, locally or globally.

This research also revealed that respondents in the study area are still dependent on oral tradition to transmit their indigenous knowledge with 41% saying so. For example, the aqua farmers claimed they know the best season to harvest *dalus* through experience and local knowledge that are passed down to them by their parents. It is recommended that this traditional knowledge be documented and their efficacy be verified by appropriate bodies like universities and research agencies. Efforts should also be made to enhance the

indigenous knowledge whenever and wherever applicable to make it more useful and current. The local or indigenous knowledge can also be shared with others who are having similar issues. In this study it can be concluded that the process of diffusion is effective.

Obviously, in terms of indigenous knowledge the study finds that not much communication gap occurs. However, in relations to new knowledge from the government agencies or universities or research bodies' communication gap or breakdown do happened. In this case study apparently no diffusion of innovation happened. Thus, it is imperative for these institutions to improve their communication so that relevant information gets to the beneficiary publics soonest for it to be useful in improving their life.

This study finds it feasible for the local authority and relevant agencies like tourism board to develop the natural beauty associated with the area and establishing a food court that cater for local seafood like the *dalus* as the main attraction. However, the relevant authorities must make sure that the harvesting of the aqua life in the area including the *dalus* is sustainable. The local authority must also make the environment, especially the water quality of the area remain unpolluted if not pristine as it should be. This is essential to ensure the public health aspect of not only the gatherers or communities are protected but also the consumers.

Efforts must also be made to promote the commercial, nutritional and medical value of *dalus*. For this effort the big media as well as the small media must be utilized. A special homepage on *Batu Payung* as a tourist destination and the products it can offer like the *dalus* can be established with the young people of the area being given the responsibility to manage it.

Acknowledgement

This work was supported by Environmental Science program of Faculty Science and Natural Resource (FSSA) of Universiti Malaysia Sabah and researchers own fund. Many thanks also go to the *Batu Payung*, Tawau community for their cooperation which made this research possible.

References

- Alvarez-Fernandez, Abbaspour, N., Hurrell, R., Kelishadi, R., (2014), Review on iron and its importance for human health. *Journal of Research in Medical Sciences* 19(2):164-174.
- Abu, B.N.A., Haseeb, M., & Muhammad, A., (2014), The nexus between education and economic growth in Malaysia: cointegration and Toda-Yamamoto causality approach. *Actual Problems of Economics*, 12(162):131-141.
- Ahmad T., Amjad, M., Batool, A., Adnan, M.A.J., (2016), Impact Assessment of Nutritional Education on Health and Schooling of Primary Class Students. *Sci. Int. (Lahore)* 28(2):1407-1410.
- E., Chauvin, A., Cubas, M., Arias, P., Ontanon, R., (2011), Mollusc Shell Sizes in Archaeological Contexts in Northern Spain (13200 To 2600 CAL BC): New Data From La Garma A and Los Gitanos (Cantabria). *Archaeometry* 53(5):963-985.
- Alyahya, H., El-Gendy, A.H., Al Farraj, S., El-Hedeny, M., (2011), Evaluation of Heavy Metal Pollution in the Arabian Gulf Using the Clam *Meretixmeretix* Linnaeus, 1785. *Water Air and Soil Pollution* 214:499-507.
- Ash, J., Faulkner, P., Brady, L.M., Rowa, C., (2013). Morphometric Reconstructions and Size Variability Analysis of The Surf Clam, *Atactodea (=Paphies) Striata*. *Australian Archaeology* 77:82-93.
- Atafar, Z., Mesdaghinia, A., Nouri, J., Homae, M., Yunesian, M., Ahmadimoghaddam, M., Mahvi, A.H., (2010). Effect of fertilizer application on soil heavy metal concentration. *Environmental Monitoring and Assessment* 160:83-89.
- Aziz, R.A. & Iskandar S., (2013), Working Children and Knowledge of Right To Education: A Study of Child Labour in Sabah, Malaysia. *Asian Social Science* 9(8):22-33.
- Bhadja, P., Poriya, P., Kundu, R., (2014), Community Structure and Distribution Pattern of Intertidal Invertebrate Macrofauna at Some Anthropogenically Influenced Coasts of Kathiawar Peninsula (India). *Advances in Ecology* Volume 2014. Article ID 547395, 11pages.
- Crosetiere, L., Hare, L., Tessier, A., (2006), A Field Experiment To Determine the Relative Importance of Prey and Water as Sources of As, Cd, Co, Cu, Pb, and Zn for the Aquatic Invertebrate *Sialisvelata*. *Environ. Sci. Technol.* 40(3):873-879.
- Daba, G., Beyene, F., Garoma, W., (2013), Assessment of Knowledge of Pregnant Mothers on Maternal Nutrition and Associated Factors in GutoGidaWoreda, East Wollega Zone, Ethiopia. *Journal of Nutritional Disorders & Therapy* 4:1-7.
- Ellworth, J.B. (200). *Surviving Change: A Survey of Educational Change Models*. Syracuse, N.Y.: Clearinghouse on Information & Technology, Syracuse University.
- E-Siong Tee, (2011), Development and promotion of Malaysia Dietary Guidelines. *Asia Pac J Clin Nutr* 20(3).
- Gamble, P., & Blackwell, J. (2001). *Knowledge Management. A state of the art guide*. London: Kogan Page. IN: Hudcova, S. 2014. Tools of Internal Communication from Knowledge Transfer Perspective. *Journal of Competitiveness*. 6(4); 50-62.
- Gemperline, P. J. 2006. *Practical Guide to Chemometric: Chapter 4: Principle Component Analysis*. Second Edition. Taylor and Francis Group, New York. Pg: 69.
- Gibson, R.S. & Ferguson, E.L., (1998), Nutrition intervention strategies to combat zinc deficiency in developing countries. *Nutr Res Rev.* 11(1):115-131.
- Hamli, H., Idris, M.H., Rajae, A.H., Kamal, A.H.M., (2015), Reproductive Cycle of Hard Clam, *Meretixlyrata* Sowerby, 1851 (Bivalvia:Veneridae) from Sarawak, Malaysia. *Tropical Life Sciences Research* 26(2):59-72.
- Hamli, H., Idris, M.H., Abu Hena, M.K., Wong, S.K., (2012), Taxonomic study of edible bivalve from selected division of Sarawak, Malaysia. *International Journal of Zoological Research* 8(1):52-58.

- Hudcova, S. 2014. Tools of Internal Communication from Knowledge Transfer Perspective. *Journal of Competitiveness*. 6(4); 50-62.
- Idris, M.H., Hamli, H., Kamal, A.H.M., Rajae, A.H., (2017), Distribution of Mineral Contents in the Selected Tissues of *Meretrixlyrata*. *Journal of Fisheries and Aquatic Science* 12(3):149-156.
- Iwaoka, C. & Okayama, T., (2009), Public Awareness and Community-Based Conservation for the Horseshoe Crab at Saikai National Park in Nagasaki Prefecture, Japan. *Biology and Conservation of Horseshoe Crabs (Springer Publisher)* 571-583.
- Khanh, N.V., Minh, V.V., Vinh, N.D., Hai, L.D., (2010), Accumulation of mercury in sediment and bivalves from Cua Dai estuary, Hoi An city. *VNU Journal of Science, Earth Science* 26:48-54.
- Lasiak, T., (1992), Contemporary shellfish-gathering practices of indigenous coastal people in Transkei: some implications for interpretation of the archaeological record. *South African Journal of Science* 88:19-28.
- Ma, G., Jin, Y., Li, Y., Zhai, F., Kok, F.J., Jacobsen, E., Yang, X., (2008). Iron and zinc deficiencies in China: what is a feasible and cost-effective strategy?. *Public Health Nutr.* 11(6):632-638.
- Mannino, M.A. & Thomas, K.D., (2002), Depletion of a Resource? The Impact of Prehistoric Human Foraging on Intertidal Mollusc Communities and Its Significance for Human Settlement, Mobility and Dispersal. *World Archaeology (Ancient Ecodisasters)* 33(3):452-474.
- Mohd Ali, S.A., Budin, K., Tair, R., F Adnan, F.A., Johani, N., (2010). Kepekatanlogamberatdalam sedimentan *Meretrix sp.* di persisir pantai Bongawan dan LokKawi, Sabah. *Borneo Science* 26.
- Mohd Hamdan, D.D, Tair, R., Agong, Rati., Adnan, M.H., Salleh. A.R., (2016). Effective Communication and Interdisciplinary Research on the Idea that Size Matter for Safer Lokan Delicacies in Sabah. *Jurnal Komunikasi Borneo Edisi Khas (Konvokesyen ke-18 UMS)* 6(1):1-23.
- Mohd Hamdan Adnan, (2012), Suara Pengguna. Kuala Lumpur: Dewan Bahasa & Pustaka.
- Mohd Hamdan Adnan (2010). Government & Political Public Relations An Introduction. Shah Alam: UPENA, Universiti Teknologi Mara.
- Mohd Hamdan Adnan and Zulkarimein Nasution (1992), Komunikasi Pembangunan Pengenalan dan Penerapan. Kuala Lumpur: Dewan Bahasa & Pustaka.
- Mustafa, A.D., Juahir, H., Yunus, K., Amran, M.A., CheHasnam, C.N., Azaman, F., Abidin, I.Z., Azmee, S.H., Sulaiman, N.H., (2015). Oil Spill Related Heavy Metal: A Review. *Malaysia Journal of Analytical Sciences* 19(6):1348-1360.
- Razak, S.A., (2015), Transformation in economic and workforce development in Sabah: An Analysis. *Journal of Borneo Transformation Studies (JOBTS)* 1(1):108-130.
- Richir, J. & Gobert, S., (2016). Trace elements in Marine Environments: Occurrence, Threats and Monitoring with Special Focus on the Coastal Mediterranean. *Journal of Environmental & Analytical Toxicology* 6(1):1-19.
- Rius, M., Kaehler, S., Mcquaid, C.D., (2006), The relationship between human exploitation pressure and condition of mussel populations along the south coast of South Africa. *South African Journal of Science* 102:130-136.
- Rogers, E. (1995). Elements of Diffusion. In *Diffusion of Innovations* (4th ed. Pp 1-37). New York: The Free Press.
- Roohani, N., Hurrell, R., Kelishadi, R., Schulin, R., (2013), Zinc and its important for human health: An integrative review. *J Res Med Sci.* 18(2):144-157.
- Ruzita, A.T., Wan Azdie, M.A.B., Ismail M.N, (2007). The Effectiveness of Nutrition Education Programmes for Primary School Children. *Malaysia Journal of Nutrition* 13(1):45-54.

- Sharif, R., Chong, E., Meng, C.K., (2016), Human health risk assessment of heavy metals in shellfish from Kudat, Sabah. *Mal J Nutr* 22(2):301-305.
- Simsir, N.C., (2012), An econometric analysis of the relationships between economic growth and agricultural credits for poor-growth in Turkey. *International Journal of Social Sciences and Humanity Studies* 4(2):355-364.
- Sugesh, S., Mayavu, P., Sharma, S., (2014), Cytotoxic effects of two edible bivalves *Meretixmeretix* and *Meretixcasta*. *African Journal of Pharmacy and Pharmacology*.
- Thangavelu, A., David, B., Barker, B., Geneste, J.M., Delannoy, J.J, Lamb, L., Araho, N., Skelly, R., (2011), Morphometric analyses of *Batissaviolacea* shells from Emo (OAC), Gulf Province, Papua New Guinea. *Archaeol. Oceania* 46:67-75.
- Thomas, K.D., (2015), Mollusc emergent, Part II: themes and trends in scientific investigation of mollusc and their shells as past human resources. *Journal of Archaeological Science* 56:159-167.
- Wang, Q., Liu, B., Yang, H., Wang, X., Lin, Z., (2009), Toxicity of lead, cadmium and mercury on embryogenesis, survival, growth and metamorphosis of *Meretixmeretix* larvae. *Ecotoxicology* 18:829-837.
- Warren, D.M. & Rajasekaran, B., (1993), Putting local knowledge to good use. *International Agricultural Development* 13(4):8-10.
- Yamazaki, T. & Oda, S., (2009), Changes in shell gathering in an early agricultural society at the head of Ise Bay, Japan. *Journal of Archaeological Science* 36(9):2007-2011.
- Yeh, C.Y., Huang, J.F., Lee, J.M., Schafferer, C., (2017), An economic analysis of hard clam (*Meretixmeretix*) farmer polyculture with milkfish (*Chanoschanos*), silver sea bream (*Rhabdosargus sarba*), and shrimps at different hard clam stocking densities: a case study of Yunlin County, Taiwan. *Aquaculture International* 25(3):1039-1055.
- Yusoff, H., Wan Daud, W.N., Ahmad, Z., (2013), Effectiveness of Nutrition Education vs, Non-Nutrition Education Intervention in Improving Awareness Pertaining Iron Deficiency among Anemic Adolescents. *Iran J Public Health* 42(5):467-471.