

MARICULTURE IN KUDAT AND KOTA MARUDU, SABAH

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Abstract

This study provides a profile of mariculture that is cultivation of mainly grouper in Kudat and Kota Marudu, Sabah using a structured questionnaire and in-depth interview. This study tries to survey all the mariculture operators in grouper cultivation in Kudat and Kota Marudu, Sabah, which altogether are 12 mariculture operators. 11 mariculture operators are surveyed in Kudat whilst there is only one mariculture operator found and surveyed in Kota Marudu. Generally, mariculture in grouper is relatively a medium scale business. The mariculture operators are dominated by the middle aged men. The owner of the mariculture operators is mostly Chinese. The majority of them have education only up to the secondary school level. The mariculture operators mostly own their business and learn themselves about mariculture. Mostly, they setting-up their business using their own capital. The mariculture operators acknowledge the importance of environment on their business. Women are mostly important in supporting mariculture business. The mariculture operators mostly conduct mariculture business as sub-business. Mariculture in grouper can be a good business in Kudat and Kota Marudu besides there are several challenges shall be addressed in the business. The government can contribute significantly to the development of the mariculture sector.

Keywords: Mariculture, floating cage, grouper, Kudat, Kota Marudu.

Introduction

Aquaculture is farming of aquatic organism such as fish or aquatic plants such as seaweed for food. Aquaculture can be in salt water and freshwater. Mariculture is farming of aquatic organism such as fish or aquatic plants in

marine environment. Mariculture is a branch of aquaculture¹. Mariculture implies some forms of intervention in the rearing process to enhance production such as regular stocking, feeding and protection from predators (Med Maritime Integrated Projects, 2017). Mariculture is an important economic activity for the folk in the coastal area of Sabah and becomes a supplement activity of fishery in Kudat and Kota Marudu, Sabah. It supplies not only food and nutrition as well as generates employment, business and investment opportunities in the region. Mariculture becomes an important economic activity as demand and consumption of fish increasing whereas wild fish stock declining (Afero, Miao & Perez, 2010; Grealis et al., 2017; Tran et al., 2017). Moreover, mariculture activity can contribute additional return to agriculture activity. The significance of mariculture and related activities is expected to grow in Sabah in the near future. Floating cage culture and pen culture are common methods for mariculture in Kudat and Kota Marudu, Sabah. A cage and a net pen differ from their construction. A cage has a completely rigid frame on all sides and a net pen has a rigid frame only around the top. However, the terms cage and net pen are often used interchangeably. Marine cages are often called net pens even though they have completely rigid frames and vice versa (Masser, 1988, 1997). The bottom of a pen is the natural bottom whereas a cage always has net separating the cage from the natural bottom. Cage culture in mariculture encloses fishes in cages put into the sea, which the sea water passes freely between fishes and the nets. The floating cage culture cages are usually made of woods, blue barrels and nets. The advantages of the floating cage culture are relatively least construction cost, harvesting is simple and observation and sampling of fish is simple. The disadvantages of the floating cage culture are feed must be fresh and nutritionally complete, disease can be spread rapidly and poaching is a potential problem (Masser, 1988, 1997; Vikaspedia, 2018).

Sabah is located in the coral triangle, which is very rich in biodiversity (Wikipedia, 2018). Therefore, mariculture can be potentially developed intensively at a large scale in Sabah. This can be contributed significantly to the diversity of economic activity and development in Sabah. One key area of mariculture in Sabah is the northern part of Sabah, namely Kudat and Kota Marudu. Kudat district covers about 1,287 square kilometres, which includes Kudat Peninsular, Balambangan Island, Banggi Island, Malawali Island,

Matunggong and island nearby (DOSM, 2016). In the west of Kudat is the South China Sea and in the east of Kudat is the Sulu Sea. Kota Marudu is located in the Kudat division of Sabah. Kota Marudu district covers about 1,917 square kilometres (DOSM, 2016). Kota Marudu is bordered by the districts of Kudat, Kota Belud, Pitas and Beluran. In 2010, the population of Kudat district was estimated 83,140. The main ethnic of population in Kudat was other bumiputera, mainly Rungus, which was about 54.6 per cent of population in Kudat. Bajau, Chinese and Kadazan-Dusun were about 21.3 per cent, 5.9 per cent and 4.4 per cent of population in Kudat, respectively. Non-Malaysian citizen mainly foreign immigrants from Mindanao and the Sulu archipelago was about 10.1 per cent of population of Kudat (DOSM, 2013). In 2013, the population of Kota Marudu district was estimated 60,374. The main ethnic of population in Kota Marudu was Kadazan-Dusun, which was about 62.3 per cent of population in Kota Marudu. Other bumiputra, Bajau, non-Malaysian citizen and Chinese were about 15.3 per cent, 14.1 per cent, 2.8 per cent and 2.6 per cent of population of Kota Marudu, respectively (DOSM, 2013). Kudat and Kota Marudu both are suitable geographical area for mariculture compared to other areas in the northern part of Sabah. The main areas of mariculture in Kudat are located in Esplanade Sidek and Tampakan Bay whereas in Kota Marudu, the only one mariculture operator is found in Taritipan village, Kota Marudu. There are about 10 mariculture operators registered with Kudat Town Board. Those mariculture operators mostly are operated by Chinese such as CK Marine Product Sdn. Bhd., Kingfisher Sea Product and Kauli Kudat Sea Product.

This study provides a profile of mariculture, that is cultivation of mainly grouper in Kudat and Kota Marudu, Sabah using a structured questionnaire and in-depth interview the mariculture operators, Department of Fisheries Sabah, Kudat and Kudat Town Board. The structured questionnaire plans to cater demography, business nature and financing, environmental knowledge, perception on the role of women and expectation from government of mariculture operators. The analysis of the structured questionnaire is based on descriptive statistics using Statistical Package for the Social Sciences (SPSS). In addition, this study discusses production and cost as well as prospects and challenges of the mariculture in grouper in Sabah. The outcome of this study can enhance the fundamental knowledge for the potential mariculture operator in grouper and related policy makers.

The Profile of the Mariculture Operators in Kudat and Kota Marudu, Sabah

This study tries to survey using a structural questionnaire for all the mariculture operators in cultivation of mainly grouper in Kudat and Kota Marudu, Sabah. There are altogether 12 mariculture operators surveyed. 11 mariculture operators are surveyed in Kudat whilst there is only one mariculture operator found and surveyed in Taritipan village, Kota Marudu. Previously, there were other mariculture operators in Kudat and Taritipan village but already stopped operation. These mariculture operators range from owning less than 10 cages, 10 – 50 cages and more than 50 cages. The survey was conducted mainly in May and June 2017. The main aim of the structural questionnaire survey is to provide a profile of the mariculture operators in Kudat and Kota Marudu and to examine issues related with the mariculture operators. The mariculture operators in Kudat mainly rear grouper and some mariculture operator's rear grouper and some prawns whilst the only mariculture operator in Kota Marudu rears grouper, soft-shell crab and green mussel.

The results of the structured questionnaire are as follows. The respondents are 11 men (91.7 per cent) and 1 woman (8 per cent). Most of the respondents are aged between 31 – 50 years (65.8 per cent). The races of the respondents are Chinese (50 per cent), Bajau (41.7 per cent) and Kadazan-Dusun (8.3 per cent). The religions of the respondents are Buddha (41.7 per cent), Islamic (41.7 per cent) and Christian (16.7 per cent). The education levels of the respondents are mostly primary and secondary schools (66.6 per cent). The respondents mostly have 8 – 9 persons in a household.

The mariculture operators mostly own their business, that is, 83.3 per cent whilst partnership is 16.7 per cent. The mariculture operators mostly have experience between 1 – 20 years of experience (91.7 per cent). The mariculture operators generally learn mariculture by themselves (91.7 per cent).

The mariculture operators finance their business using loan (58.3 per cent), own capital (25.0 per cent), capital from family (8.3 per cent) and loan and capital from family (8.3 per cent). The mariculture operators get their loan mostly from bank (41.7 per cent) and other sources, that is other than

bank (58.3 per cent). About 41.6 per cent of the mariculture operators agree that it is easy to get loan from bank for doing mariculture business. Many procedures are required to apply for bank loan.

The mariculture operators mostly agree and strongly agree that environmental is important for mariculture activity. They chiefly agree and strongly agree that chemical, water pollution, waste, water quality, climate change and water temperature will strongly affect their mariculture business.

The mariculture operators agree that women are not important directly involving mariculture activities (66.7 per cent). However, the mariculture operators agree that women are more important in supporting their mariculture activities such as providing food (16.7 per cent) and others, that is taking care of their children and doing household works (83.3 per cent).

The mariculture operators agree that government should support more their business, provide more incentives and allowances to mariculture business, provide more finance assistance, provide more training and technical services and at the same time reduce red-tape in obtaining licence. Moreover, the mariculture operators hope that government should provide better marine security.

On the whole, mariculture in grouper is relatively a medium scale business in Kudat and Kota Marudu, Sabah. Mariculture business is sub-business to many of the mariculture operators. The mariculture operators are dominated by the middle aged men. The owner of the mariculture operators is mostly ethnic Chinese. The majority of the mariculture operators have education only up to the secondary school level. The mariculture operators largely own their business with about 20 years of experience in mariculture business. They principally learn themselves about mariculture. The mariculture operators are usually setting-up their business using their own capital and or borrowing from their family or relative and bank. The mariculture operators acknowledge the importance of environment change on their business. Women are generally important in supporting mariculture business. The government can contribute significantly to the development of the mariculture sector.

Species

Grouper is mainly reared in Kudat and Kota Marudu, Sabah. Grouper in nature usually found in shallow coral reefs, rocky bottoms and tidal pools. Grouper is fast growing species and can reach to approximately 500 grammes in about 9 – 12 months (Afero, Miao & Perez, 2010). Grouper has high price and high demand in the local and overseas markets. Grouper consists of various species such as camouflage grouper (*Epinephelus polyphekadion*), green grouper (*Epinephelus coioides*), tiger grouper (*Epinephelus fuscoguttatus*), banana grouper (*Plectropomus leopardus*), marble grouper or flowery grouper (*Plectropomus maculatus*) and rat grouper (*Cromeleptis altivelis*). Each species of grouper has different pattern on their body. The price of each species of grouper is different and depending on demand.

Each mariculture operator focuses on cultivating certain species of grouper at a time. For example, CK Marine Product Sdn. Bhd. focuses on cultivating tiger grouper, flowery grouper, camouflage grouper and barred-cheek coral trout (*Plectropomus maculatus*). Among the four species of grouper, tiger grouper can mature very fast and live in crowded environment. Moreover, tiger grouper can be fed efficiently. Furthermore, tiger grouper has high demand and high price, principally in the overseas market (Luo et al., 2005).

Hybrid grouper is produced from the eggs of tiger grouper combined and the sperm of giant grouper (*Epinephelus lanceolatus*) using in-vitro fertilisation method. Hybrid grouper can mature faster and able to withstand the vagaries of environmental conditions caused by climate change (Sario, 2016). A hybrid grouper can reach the weight about 1.2 – 1.5 kilogrammes within five months. Besides grouper, some mariculture operators rear some prawns, soft-shell crabs and green mussels.

Production and Cost

There are two main methods of mariculture for grouper in Kudat, namely floating cage culture and pen-culture. The floating cages require net, that is, black nylon net, blue barrels and wood. For each floating cage, two layers

of nets are used to ensure the net would not be easily damaged by sea wave and grouper would not escape from the floating cage. The blue barrels are used to float the cages. The number of blue barrels used for a floating cage depends on the size of the floating cage. The size of the floating cage in one mariculture operator is likely not the same with the size of the floating cage in another mariculture operator. For example, the blue barrels required for one floating cage with the size of 10 feet of width, 20 feet of length and 10 feet of depth is about 10. The blue barrels required for two floating cages with the same size of floating cage is about 17 as one side of the two floating cages can share the same blue barrels. The blue barrels required for three floating cages with the same size of floating cage is about 24 as two sides of the middle floating cage can share the same blue barrels and so forth. Bornean ironwood (*Eusideroxylon zwageri*) is commonly used for the frame of the floating cages. Bornean ironwood is durable and resistant to insects, bacteria, fungi and marine borers. The use of Bornean ironwood for the frame of the floating cages can last up for about ten years. Conversely, the use of other type of low-quality wood for the frame of the floating cages can last only for a few years.

The floating cages should be regularly maintained and monitored for cleanliness and completeness of the floating cages. The number of groupers to be reared in one floating cage depends on the size of the floating cage. The size of a floating cage can be 10 feet of width, 20 feet of length and 10 feet of depth, which can accommodate about hundreds of groupers. The optimum of groupers in a floating cage shall be identified to produce maximum yield of groupers cultivation. Stocking density is associated with survival rate, growth, shape, pigmentation, health, water quality and production. An increase in stocking density within a cage can lead to an increase in production per unit area. Nonetheless, a high stocking density causes stress in grouper and thus affecting the growth of grouper. A high stocking density also increases the incident of disease. The optimal stocking density in a cage depends on age, size of grouper species and cage size (Hwang et al., 2014). The moss on the nets of the floating cages may need to be cleaned once a week or depending when the nets are dirty. The workers will drive into the sea equipped with oxygen for hour to remove the dirty nets with the moss and to change with the clean nets on the floating cages. The nets with the moss will be bought

out from the sea and then washed and brushed by using water at the site of the floating cages. The dirty nets will be replaced before feeding groupers in the floating cage. Grouper will be separated based on their size into different floating cage for a better rearing purpose after several months. The yellow medicine imported from Japan will be used to cure bacteria on grouper's skin. Also, when grouper is sick, it will be secluded from other groupers.

Some mariculture operators use the floating cages and pen-culture to rear grouper at the same time. For example, Kingfisher Sea Product owns 24 cages for pen-culture and some floating cages. However at the time of field survey, only 16 cages of pen-culture were used to rear hybrid grouper, tiger grouper, white fish (*Caranx sexfasciatus*) and camouflage grouper. It takes months to construct pen-culture. According to Thomas Wong Sin Hin from Kingfisher Sea Product, he has been guided by Department of Fisheries Sabah, Kudat for mariculture activity. Besides, Department of Fisheries Sabah, Kudat has provided some materials to him, that is nets, ropes and blue barrels to construct the floating cages. The sites of the floating cages in some mariculture operators are installed with the spotlight to evade illegally with intent to commit a crime, especially burglary. The mud crabs are placed in the plastic baskets and then the plastic baskets are placed into the floating cage. The mussels are reared in about two feet inside the water. In Taritipan village, Kota Marudu, the cleaning of the floating cages is not very necessary because the net was not clung too dirty by the green moss.

The site of the floating cage should be good water quality and should be located where preselling winds blow across it (Masser, 1997). There is not much difference between floating cage culture and pen-culture. The floating cages can be located in the sea at least 10 feet depth from the bottom of the sea whereas pen-culture is good to locate at the sea with 6 feet depth from the bottom of the sea. Pen-culture is not easily damage by big wind and sea wave compared with the floating cages.

A scheduled feeding is important for growing of grouper. The mariculture operators have their own regular feeding time. For example, CK Marine Product Sdn. Bhd. feeds its groupers at 2.00 p.m. or 2.30 p.m. for almost every day. The feeding time depends on the number of floating

cages. It can take about 2 hours for feeding about hundreds of floating cages of groupers. Trash fish comprises different species of small fishes mainly mackerel and sardinella fimbriata will be chopped into small pieces by using the machine imported from China before feeding groupers. Trash fish is chopped to appropriate to mouth size of grouper and feed to grouper until satiation (Afero, Miao & Perez, 2010). Some groupers eat while the feeding materials are floating on the surface of water whereas some groupers eat when the feeding materials fell into about the bottom of the floating cages. Much of the uneaten feeding materials would drop into the bottom of the sea. Thus, it can be huge waste and cost to the mariculture operators. Sims et al. (2005) report that about 30 – 50 per cent of trash fish fed to grouper can be lost during the feeding process. Feeding losses from trash fish are 2 – 4 times higher than in pelleted feeds. Afero, Miao and Perez (2010) find that a large scale production produces more waste in using trash fish than small scale production. The cost of production a kilogramme of grouper using trash fish is directly correlated to feed conversion ratio, that is, the ratio or rate measuring of the efficiency of grouper converting trash fish into desired size. An increase in feed conversion ratio would positively increase the cost of producing a kilogramme grouper (Afero, Miao & Perez, 2010). For small or medium size of grouper, that is about 8 – 10 centimetres, the mariculture operators usually feed them every day. For larger size of grouper, that is, about 15 centimetres and above, the mariculture operators feed them once in 2 or 3 days. For the fingerlings, the mariculture operators usually feed them with fertilizer bought from Kolombong, Kota Kinabalu. When the fingerlings become larger, the mariculture operators feed them with chopped fishes. Giant grouper with the size of 15 – 40 kilogrammes would not be fed every day to avoid over eating, which could cause dead itself. Only this species of grouper has this kind of problem. The amount of the feeding materials depends also the size and number of groupers. Groupers with larger size require more feeding materials. For some mariculture operators, the survival rate of the fingerlings is said to be about 50 per cent, which is considered low. A high survival rate of the fingerlings, that is, 80 per cent or above is said able to generate more profitability to the mariculture operators (Afero, Miao & Perez, 2010). Also, feeding depends on the available of trash fish that the mariculture operators can get from the fish market, namely Kompleks Ko- Nelayan Kudat.

Grouper will be harvested after its reach certain size or depending on market demand. Usually, grouper will be harvested when it reaches the size about 500 – 800 grammes or about 1 kilogramme. The mariculture operator in Kota Marudu will harvest its grouper when its reach 700 – 800 grammes, which usually will take about 6 – 7 months. The demand of groupers also depends on the demand from the restaurants. When there is demand, the mariculture operators will send their product to the restaurants.

Mariculture in grouper is a labour intensive business and dominated by male labour. Aslan et al. (2015) also report that grouper farming in South East Sulawesi, Indonesia, which labour is dominated by male with female to male ratio is 1 to 3. Labours are required to feed groupers, to clean and maintain the floating cages and to harvest groupers (Afero, Miao & Perez, 2010). A high labour cost can make the mariculture in grouper business not profitable.

The mariculture operators mostly employ workers from the Philippines and only a few are local workers. The foreign workers are diligent in completing their task compared to local workers. For example, previously a few local workers in an mariculture operator worked for about 2 – 3 months only. The local workers cannot work for a long hour under the hot sun and cannot resist for motion sickness. The mariculture operators usually will provide shelter, electricity and water on the site of the floating cages and the workers are allowed to eat some groupers. However, the workers have to buy their own vegetables from the market. The part time workers will be employed if there is a need. The mariculture operators will also provide fresh water to their workers using blue barrel transported from the town.

Production cost is the primary factor influencing profitability in grouper farming (Afero, Miao & Perez, 2010). The costs are mainly the feeding materials, labour costs, fingerlings, construction cost of the floating cages, licence and utilities such as fuel, oxygen, electricity and water bills. The material required to construct the floating cages are wood, blue barrels and nets. The labour costs and material costs required depend on the size and number of the floating cage to be constructed. The cost of one blue barrel is about RM70.00. Licence shall be renewal every year. Licence is issued depending on the lot of area for the floating cage and whether there is

shelter built at the site. For example, the licence for one lot of area at Jetty of Esplanade Sidek is RM300.00 per year and the licence for one lot of area with shelter built at the site is RM500.00 per year. Fixed cost is usually decreased with increasing production scale (Afero, Miao & Perez, 2010).

The variable costs include maintaining costs for the floating cages, that is cleaning the net and repairing the floating cage. The cleaning of the net can be weekly. The worker can be divided into experienced, inexperienced and part-time worker. The salary is different for different type of worker. For experienced worker, the salary can be more than RM1,000.00 a month. For inexperienced worker, the salary is likely about RM1,000.00 a month. A part-time worker is usually paid based on daily basis, that is, about RM25.00 per day. The part-time worker is usually hired when there is plentiful of seafood stock or when there is the need to wash the net. The number of worker employed depends on the size of the mariculture operator business or the number of the floating cages. The amount of the feeding materials depends on the amount of groupers in the floating cages. The amount of trash fish required to feed about hundreds of the floating cages of groupers is about 1.8 tonne per day, which is equivalent to RM1,800.00 (1,800 kilogrammes × RM1.00 = RM1,800.00). For example, CK Marine Product Sdn. Bhd. at jetty of Esplanade Sidek own hundreds of the floating cages. The estimated cost is about RM784,000.00 The three major costs are the feeding materials (55.1 per cent), labour costs (26.0 per cent) and fingerlings (12.8 per cent). These costs consist about 93.9 per cent of the overall costs (Table 1). Hence, efficient management of these costs would improve profitability of the mariculture operators. The worker uses the speedboat to transport trash fish from the fish market to the site of the floating cages every day. Some mariculture operators buy trash fish directly from fishermen, which usually send trash fish to them. The mariculture operators pay a lot for water bill. They have to wash the net from the shellfish or moss to avoid any bacterial hiding there and to affect grouper. The mariculture operators also provide shelter and some food for their workers. Besides, the mariculture operators pay for electricity and water bills and fuel for the speedboat. An increased in production scale would increase variable costs except fixed costs are likely reduced and labour costs may be reduced. An increase in unit floating case in large scale production made labour to able to handle more floating cages and contributed to lower labour input (Afero, Miao & Perez, 2010).

Marketing

The mariculture operators sell their groupers normally alive to the local and overseas markets. The live groupers are sold at higher price than frozen groupers. The amount of seafood sold depends on demand and supply of the seafood. For the local market, they generally sell to the restaurants in Kudat or Kota Marudu and Kota Kinabalu such as Ocean Seafood, Welcome Seafood and Asia City and Salut restaurant in Tuaran. For the overseas market, the mariculture operators mainly sell to the restaurants in Hong Kong. The mariculture operators also sell to the seafood wholesaler in Kota Kinabalu, namely S.H. Marine Product Sabah Sdn. Bhd., which the company exports the seafood to the overseas markets such as Hong Kong, Taiwan and Peninsular Malaysia. Camouflage grouper is usually sold to the restaurants in Hong Kong. The mariculture operators export about twice a year to the restaurants in Hong Kong. At one time, the mariculture operators export about 200 – 300 kilogrammes. The export price for camouflage grouper with 500 – 800 grammes can be about RM50.00 per gramme. For the size above 1 kilogramme, the selling price can be about RM100.00 per kilogramme. Besides grouper, the mariculture operators also supply other seafood products such as soft-shell crab and prawn to the restaurants in Kota Kinabalu.

Hybrid grouper is sold at about RM40.00 per kilogramme while tiger grouper is sold at about RM35.00 per kilogramme. The prices for barred-cheek coral trout and coral trout grouper are usually a bit higher than other species of grouper. Barred-cheek coral trout grouper is sold at about RM120.00 per kilogramme while coral trout grouper is sold at about RM80.00 per kilogramme. The prices can be different from different mariculture operator and also depend on season, that is the price of grouper is likely to be higher during Chinese New Year than other time in a year as the demand for grouper from the restaurants in the overseas market will increase. For example, one kilogramme of camouflage grouper is said to be RM38.00 at CK Marine Product Sdn. Bhd. but is said to be RM40.00 at Kingfisher Sea Product (Table 2).

Giant tiger prawn (*Penaeus monodon*) with the size about nine inches is sold at about RM30.00 per kilogramme. Flowery Shrimp (*Penaeus sp*)

with the size about nine inches is sold at about RM70.00 per kilogramme. Greasyback shrimp (*Metapenaeus ensis*) or Sand shrimp with the size about three inches is sold at about RM35.00 per kilogramme. Flowers crab (*Portunus pelagicus*) is sold at about RM25.00 per kilogramme. The price of mud crab or mangrove crab or black crab is sold at about RM40.00 per kilogramme. The fingerlings of mud crab are regularly bought from fishermen. Some mariculture operators rear green mussel for exporting to the overseas market.

Prospects and Challenges Prospects

The increase of population leads to the increase of demand in marine food products, which cannot be satisfied solely by wild fish stocks. The rapid economic development in Asia especially in China is expected to increase the number of the middle class, which will increase seafood demand. The global demand for seafood is expected to increase dramatically in the near future. Mariculture is expected to be an alternative to commercial capture fishing to meet the expected increase in future global seafood demand (Campbell & Pauly, 2013; Grealis et al., 2017; Tran et al., 2017). Moreover, the arrival of more tourists from abroad to Sabah creates more demand for grouper. Furthermore, grouper such as camouflage grouper is only suitable to live in hot weather throughout the year, which is not suitable to be reared in other part of Far East Asia. The price of grouper is considered good to attract the mariculture operators to continue their businesses.

Water around sea of Kudat is still considered free from pollution. Besides, the temperature in Kudat is hot. It is not much difficulty to get licence from the Kudat Town Board for cultivating grouper at Jetty of Esplanade Sidek.

Mariculture activities can also attract tourists, which can add more return to the mariculture operators. For example, Thomas Wong Sin Hin from Tampakan bay diversifies its mariculture business into tourism activities such as providing tourists for snorkelling, swimming with grouper, feeding grouper and having seafood meal. Moreover, some mariculture operators organise fishing trip to open sea and some mariculture operators do small resort business.

Challenges

The main challenge to the mariculture operators is the fingerlings. It is usually a challenge to the mariculture operators to get good and cheap fingerlings from fish hatchery. Some mariculture operators get the fingerlings from abroad such as from Taiwan and Indonesia and also from Peninsular Malaysia. The fingerlings can be deformed such as half head become larger or the mouth can be gruff. The fingerlings can be deformed and only be known after they grown up to certain size. This can cause huge lost to the mariculture operators as buyer unlikely to buy those deformed grouper.

Mariculture creates negative environmental impact, that is pollution to the marine environment and changes its biodiversity. Mariculture introduces uneaten feed, which is characterised by high levels of organic matter that supports the growth of bacteria around the floating cages. Decomposition of this organic matter by bacteria not only consumes oxygen but also liberates nutrients and may result in hypoxia in the water and sediments, nutrient enrichment and algae blooms and eutrophication in the surrounding water. The sustainable management of the floating cages requires properly locating the floating cages for hydrodynamic regimes and stocking density (Château et al., 2015; Li & Gu, 2016). The intensive mariculture activity in the coastal area can cause the negative effects on water quality such as eutrophication and future ocean acidification. Poor environmental conditions will negatively affect the survival of cultivated organisms (Li et al., 2017). Moreover, mariculture activity can cause negative impact on coral reefs. Cage farms may negatively impact the reef in three major ways namely, being a point source for excess nutrients, increased sedimentation and chemicals such as antibiotics by using coral fish as feed and by using wild caught coral reef species as seedlings (Hedberg et al., 2017).

Water quality affects the health of grouper (Aslan et al., 2015). The water pollution can be due to diesel spill out from fishing boats, waste disposal and so forth. The small groupers will strongly affected by the diesel spill out from fishing boats than the large groupers. The diesel spill out from boats can cover sea surface from oxygen. Besides, grouper also faces the

moss problem. The green moss will grow quickly on the net especially after raining day. This moss will attract bacteria, which affects grouper until sick. Therefore, the workers need to wash the net of the floating cages frequently so that the net shall be free from green moss. The clean net of the floating cages is important for groupers to mature quickly and live healthy.

The mariculture operators at Jetty of Esplanade Sidek may have to move their operation to Tampakan Bay. The area of Jetty of Esplanade Sidek is not suitable for mariculture because it spoils the tourists' view at Jetty of Esplanade Sidek. Tampakan Bay is a strategic location for mariculture because it is further away from Kudat Town and therefore it is less polluted and interrupted. The problem is moving cost of the floating cages from Jetty of Esplanade Sidek to Tampakan Bay. Moreover, the feeding cost can increase due to further distance to transport trash fish from the fish market at Kudat Town to Tampakan Bay. The price of trash fish can be expensive due to demand and supply. The water at Tampakan Bay is mainly collected from rainwater. When there is lack of water, the worker will use blue barrel, which one blue barrel can be filled with 400 litres, to get water from Kudat Town. The normal price of trash fish is about RM1.00 per kilogramme. The price of trash fish can increase to about RM1.40 per kilogramme due to short supply. The mariculture operators may have to reduce their feeding frequently such as feeding one in two days and so forth because higher cost of feeding. This can reduce the growing of groupers. The increase of minimum wage and the fuel price would also increase the operation cost of the mariculture operators. Exports of the mariculture operators in the overseas market also face competition from exports of other suppliers in other places such as in Indonesia and Peninsular Malaysia. The bird, namely cranes eat the fingerlings or the small size of groupers in the floating cages. Therefore, the floating cages for the fingerlings or the small size of should be covered by net. The storm causes tidal wave, which can damage the net of the floating cages. In 2013, the red tiles attacked and caused the fingerlings die. Water temperature influences food intake, oxygen consumption, protein synthesis, metabolic rate and survival rate of grouper (Sun et al., 2015; Zhang et al., 2018). The hot water temperature can wound or damage some groupers' skin and also can cause grouper to die.

Conclusion

This study aims to provide a profile of mariculture in grouper in Kudat and Kota Marudu, Sabah. The mariculture operators are relatively a medium scale business. The mariculture operators are dominated by the middle age Chinese men with education mostly not up to the secondary school level. The mariculture operators mostly own their business and they learn mariculture business by themselves. The mariculture operators mostly borrow capital from bank to setting-up their mariculture business. The mariculture operators understand environmental is important for their mariculture business. Women are important in supporting mariculture business (Chin, 2018). The government can promote and develop the mariculture sector successfully.

Grouper is mainly reared in Kudat and Kota Marudu, Sabah. There are many species of groupers. Every mariculture operator focuses on certain species of groupers at a time. Grouper has high price and high demand in the local and overseas markets. Moreover, grouper can be reared easily and can mature relatively fast. Different species of grouper has different price. The floating cage culture and pen-culture are two popular methods for mariculture in Kudat. In Kota Marudu, the only cage culture is used by the mariculture operator. The mariculture operators sell their groupers to the local and overseas markets. For the local market, they sell mainly to the restaurants in Kota Kinabalu. For the overseas market, they sell mainly to the restaurants in Hong Kong.

Mariculture can contribute to the local and state economy as a source of foreign exchange earnings, employments and livelihoods. The domestic demand for mariculture is expected to increase given by population growth, higher income, urbanisation and consumer preferences to fish due to health concerns. At the same time, capture fisheries are expected to decrease due to over fishing and the destruction of fish habitats. The importance of mariculture to the economy is expected to increase in the future (Grealis et al., 2017; Tran et al., 2017). The increase of the arrival of tourists in Sabah especially from China also leads to more seafood demand. Kudat and Kota Marudu are suitable for mariculture activities as Sabah is located in the coral triangle, which is prosperous in marine resources. Mariculture can be developed together with

the tourism activities, which can generate higher return to the mariculture operators. One main challenge of mariculture is lack of good quality and cheap fingerlings. Disease can be a real treat to mariculture. Cost of disease outbreaks and expenses of disease control can be huge (Sindermann, 1984). Moreover, the water pollution can destroy mariculture activities. Furthermore, the feeding cost can increase in the near future. This can increase the prices of groupers. Water temperature is one substantial factor that influences the growth of grouper. De et al. (2016) report that the optimum water temperature for growth and condition of tiger grouper and giant grouper is between 26°C to 30°C. However, the optimum water temperature for growth and condition of other species of grouper can be different. For example, Sun et al. (2015) find that water temperature of 30°C is good for the leopard coral grouper.

The mariculture operators can construct more floating cages to increase supply of groupers and to expand their business. Therefore, fish hatchery for the fingerlings of the hybrid grouper and other valuable species of fishes, prawns and crabs shall be developed to supply sufficiency of the fingerlings to the mariculture operators. The high quality of the fingerlings shall be sold at reasonable prices to the mariculture operators. Presently, many mariculture operators cannot continue their business because of lack of the fingerlings. High quality of the fingerlings can increase the survival rate of groupers. A small scale of mariculture production is unlikely to ensure the successfulness of the business and investment is lucrative. Conversely, a medium or large scale of mariculture production is likely economically viable business. Some mariculture operators shift to other mariculture activity such as rearing sea cucumber because of high price of the feeding materials and labour costs. The young generation with more knowledge and energetic shall be encouraged and attracted to expand and develop the mariculture sector. Nonetheless, mariculture activity is a tough job and therefore not many people can stand in the mariculture environment. The survival rate of the fingerlings, sales price, scale of production and production cost are the main variables to affect the profitability of the mariculture operators. Moreover, the mariculture operators shall focus on the species of grouper that have high demand and high price. There is high demand and high price for soft-shell crab because of its delicious meat but the fingerlings of soft-shell crab are hard to get. The mariculture operators may have to diversity their species of groupers to other seafood such as soft-shell crab and green mussel.

The government shall formulate plans, strategies and interventions that ensure sustainable development of the mariculture sector. The government may support and adopt the blue economy proposed by World Bank and United Nations Department of Economic and Social Affairs (2017) to develop the mariculture sector. The government shall support mariculture activities by providing finance, subsidies and assistances such as the fingerlings and constructing materials for the floating cages. The government shall provide more programmes related to mariculture activities and encourage entrepreneurs in the industry. Education of production and unified standards in the mariculture sector can assist development of the mariculture sector in the future (Palm et al., 2015). The government shall provide more or upgrading basic infrastructure such as jetty, road, electricity and water. The government should prevent sea pollution near the mariculture sites to avoid the aquatic life dying and to destruct coral reef. The security of the area shall be maintained and free from strangers or pirates.

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Note

¹ See <http://www.differencebetween.net/miscellaneous/difference-between-aquaculture-and-mariculture/>.

References

- Afero, F., Miao, S. & Perez, A.A. (2010). Economic analysis of tiger grouper *Epinephelus fuscoguttatus* and humpback grouper *Cromileptes altivelis* commercial cage culture in Indonesia. *Aquaculture International*, 18, 725 – 739.
- Aslan, L.O.M., Iba, W., Bolu, L.O.R., Ingram, B.A., Gooley, G.J. & de Silva, S.S. (2015). Mariculture in SE Sulawesi, Indonesia: Culture practices and the socioeconomic aspects of the major commodities. *Ocean and Coastal Management*, 116, 44 – 57.
- Campbell, B. & Pauly, D. (2013). Mariculture: A global analysis of production trends since 1950. *Marine Policy*, 39, 94 – 100.
- Château, P.A., Huang, Y.C.A., Chen, C.A. & Chang, Y.C. (2015). Integrated assessment of sustainable marine cage culture through system dynamics modelling. *Ecological Modelling*, 299, 140 – 146.
- Chin, M. (2018). Role for women in aquaculture sector. *Daily Express*, Wednesday, 21st March 2018.
- De, M., Abd. Ghaffar, M., Bakar, Y., Cob, Z.C. & Simon Kumar Das, S.K. (2016). Optimum temperature for the growth form of tiger grouper (*Epinephelus fuscoguttatus* ♀) × Giant Grouper (*E. lanceolatus* ♂) Hybrid. *Sains Malaysiana*, 45 (4), 541 – 549.
- Department of Statistics Malaysia (DOSM), (2013). *Population distribution and basic demographic characteristics 2010*. Putrajaya, Malaysia: Department of Statistics Malaysia.
- Department of Statistics Malaysia (DOSM), (2016). *Yearbook of statistics, Sabah 2015*.
- Putrajaya, Malaysia: Department of Statistics Malaysia.
- Grealis, E., Hynes, S., O'Donoghue, C., Vega, A., Van Osch, S. & Twomey, C. (2017). The economic impact of aquaculture expansion: An input-output approach. *Marine Policy*, 81, 29 – 36.
- Hedberg, N., Stenson, I., Kautsky, N., Hellström, M. & Tedengren, M. (2017). Causes and consequences of spatial links between sea cage aquaculture and coral reefs in Vietnam. *Aquaculture*, 481, 245 – 254.
- Hwang, H.K., Son, M.H., Myeong, J.I., Kim, C.W. & Min, B.H. 2014. Effects of stocking density on the cage culture of Korean rockfish (*Sebastes schlegeli*). *Aquaculture*, 434, 303 – 306.
- Li, H., Li, X., Li, Q., Liu, Y., Song, J. & Zhang, Y. (2017). Environmental response to long-term mariculture activities in the Weihai coastal area, China. *Science of the Total Environment*, 601 – 602, 22 – 31.
- Li, M. & Gu, J.D. (2016). The diversity and distribution of anammox bacteria in the marine aquaculture zones. *Applied Microbiology and Biotechnology*, 100, 8943 – 8953.

- Luo, Z., Liu, Y., Mai, K., & Tian, L. (2005). Advances in the Study on Nutrient Requirements of Grouper (*Epinephelus* sp.): A Review. *Journal of Ocean University of China*, 4(2), 93-98.
- Masser, M. (1988). What is cage culture? *Southern Regional Aquaculture Centre (SRAC) Publication No. 160*.
- Masser, M. (1997). Cage culture site selection and water quality. *Southern Regional Aquaculture Centre (SRAC) Publication No. 161*.
- Med Maritime Integrated Projects. (2017). Marine aquaculture. http://www.medmaritimeprojects.eu/download/ProjectMediamer/Final_factsheets/AIo_Aquaculture_factsheet.pdf. Retrieved on 20th August 2017.
- Palm, H.W., Yulianto, I., Theisen, S., Rueckert, S. & Kleinertz, S. (2015). *Epinephelus fuscoguttatus* mariculture in Indonesia: Implications from fish parasite infections. *Regional Studies in Marine Science*, 2, 54 – 70.
- Sario, R. (2016). Scientists breed 'super grouper'. *The Star Online*, Sunday, 6th March 2016.
- Sim, S.Y., Rimmer, M.A., Toledo, J.D., Sugama, K., Rumengan, I., William, K.C. & Phillips, M.J. (2005). *A Practical guide to feeds and feed management for cultured grouper*. No. 2005-02. Bangkok, Thailand: the Asia-Pacific Marine Finfish Aquaculture Network (NACA).
- Sindermann, C.J. (1984). Disease in marine aquaculture. *Helgolhnder Meeresunters*, 37, 505 – 532.
- Sun, Z., Xia, S., Feng, S., Zhang, Z., Rahman, M.M., Rajkumar, M. & Jiang, S. (2015). Effects of water temperature on survival, growth, digestive enzyme activities, and body composition of the leopard coral grouper *Plectropomus leopardus*. *Fisheries Science*, 81, 107 – 112.
- Tran, N. Rodriguez, U.P., Chan, C.Y., Phillips, M.J., Mohan, C.V., Henriksson, P.J.G., Koeshendranad, S., Suri, S. & Hall, S. (2017). Indonesian aquaculture futures: An analysis of fish supply and demand in Indonesia to 2030 and role of aquaculture using the AsiaFish model. *Marine Policy*, 79, 25 – 32.
- Vikaspedia. (2018). Cage culture in aquaculture. <http://vikaspedia.in/agriculture/fisheries/fish-production/culture-fisheries/types-of-aquaculture/cage-culture-in-aquaculture>. Retrieved on 5th March 2018.
- Wikipedia. (2018). Coral triangle. https://en.wikipedia.org/wiki/Coral_Triangle. Retrieved on 5th March 2018.
- World Bank and United Nations Department of Economic and Social Affairs. (2017). *The potential of the blue economy: increasing long-term benefits of the sustainable use of marine resources for small island developing states and coastal least developed countries*. Washington DC, United States: World Bank.
- Zhang, Z., Yang, Z., Ding, N., Xiong, W., Zheng, G., Lin, Q. & Zhang, G. (2018). Effects of temperature on the survival, feeding, and growth of pearl gentian grouper (female *Epinephelus fuscoguttatus* × male *Epinephelus lanceolatus*). *Fisheries Science*, 84, 399 – 404.

Appendices

Table 1 Estimated costs for hundreds of the floating cages

	RM	%
Construction costs for cages	20,000	2.6
Fingerlings (RM5 × 20,000 groupers = RM100,000)	100,000	12.8
Yearly license for 2 lots of area with shelters (RM500 × 2 lots = RM1,000)	1,000	0.1
Feeding materials (RM1 × 1,800 kilogrammes × 20 days × 12 Months = RM432,000)	432,000	55.1
Salary (RM1,000 × 17 workers × 12 Months = RM204,000)	204,000	26.0
Water (RM1,250 × 12 months = RM3,000)	3,000	0.4
Oxygen tank (RM2,000 × 12 months = RM24,000)	24,000	3.1
Total	784,000	100.0

Notes: RM is Ringgit Malaysia. % is percentage. The other costs such as oxygen, fuel for the speedboat and electricity are not available and therefore are not included in the calculation.

Source: CK Marine Product Sdn. Bhd., 2017

Table 2 The prices of selected sea products from different mariculture operators CK Marine Product Sdn. Bhd.

Note: The prices (Size: 9 inches) are based on a point of time in 2017 and likely to be different at different point of time in 2017.

Source: CK Marine Product Sdn. Bhd., 2017.

Kingfisher Sea Product

No.	Species	Price (RM/ kg)
1	Hybrid grouper	40.00
2	Tiger grouper (<i>Epinephelus fuscoguttatus</i>)	35.00
3	Barred-cheek coral trout (<i>Plectropomus maculatus</i>)	80.00
4	Coral trout grouper (<i>Plectropomus leopardus</i>)	120.00
5	Camouflage grouper (<i>Epinephelus polyphekadion</i>)	40.00
6	Giant grouper (<i>Epinephelus lanceolatus</i>)	25.00
7	Flower shrimp (<i>Penaeus Sp</i>) (Size: 9 inches)	70.00
8	Greasyback shrimp or sand shrimp (<i>Metapenaeus Ensis</i>) (Size: 3 inches)	35.00
9	Giant tiger prawn or Asian tiger shrimp (<i>Penaeus Monodon</i>) (Size: 9 inches)	30.00
10	Flower crab (<i>Portunus pelagicus</i>)	25.00

Note: The prices displayed are based on a point of time in 2017 and likely to be different at different point of time in 2017.

Source: Kingfisher Sea Product, 2017.