Strategy for development of blood cockles (*Anadara granosa*) cultivation in Batubara Regency, North Sumatera, Indonesia

[1]Azizah Mahary, [2]Irwan Effendi, [2]Hendrik Hendrik, [2]Darwis Darwis

[1] Faculty of Agriculture, University of Asahan, Kisaran, Indonesia; [2] Faculty of Fisheries and Marine Sciences, University of Riau, Pekanbaru, Indonesia. Corresponding author: I. Effendi, helpingirwan@gmail.com

Abstract. The blood cockle (*Anadara granosa*) is a mollusk that lives in the mud intertidal zone that spread from the coast of east Africa to Polynesia. This study aims to analyze the prospects and strategies for the development of sustainable blood cockle culture based on land suitability, cultivation technology, seed availability, security, government policies and aspects of commodity marketing. This research was conducted from January to August 2022 in the coastal areas of Perupuk Village (stations 1 and 2) and Gambus Laut Village (station 3), Lima Puluh Pesisir District, Batu Bara Regency. This study used a survey method by purposive sampling based on different intertidal zones around the blood cockle culture environment. Samples were collected once a month for 5 months of observation in 3 intertidal zones, namely the lower, middle and upper intertidal zones. The water quality parameters measured were: physical parameters (temperature, brightness and substrate type), chemical parameters (pH, dissolved oxygen - DO, nitrate, ammonia), and biological parameters (plankton population condition, micro and macrobenthos). Data on cultivation activities and analysis of business development prospects were obtained by observing the location of blood cockle cultivation, and interviews with cultivators. Availability of seeds, prospects for product marketing and government policies are known from direct observations in the field, interviews with cultivators, community leaders and local governments. In term of water quality the areas are suitable for blood cockle cultivation. The market potential for this commodity is still wide open, cultivation technology can be developed, the location is relatively safe and supported by government policies. The main obstacle to development is the availability of natural seeds which are increasingly difficult to obtain.

Key Words: bivalves, clam cultivation, intertidal zone, mussel, water quality.

Introduction. Blood cockle (*Anadara granosa*) is a shellfish commonly consumed by the community of East Asia and Southeast Asia. It is called as blood cockle because it produces hemoglobin in the form of a red liquid. This bivalve inhabits the Indo-Pacific region and is spread from the east African coast to Polynesia. These animals usually bury themselves in sand or mud and live in intertidal zones. Adults blood cockle are 5 to 6 cm long and 4 to 5 cm wide (Khalil et al 2017; Efriyeldi & Effendi 2022). According to Triatmaja et al (2019), blood cockles, which contain protein (9-13%), fat (0-2%), glycogen (1-7%), omega-3, vitamin A, vitamin B12, and vitamin C, are a potentially nutrient-rich diet with significant economic value. Minerals that act as antioxidants, such as Zn, Fe, Se, and Cu, are also present in bivalves. Due to an increase in demand, fishermen actively collect these invertebrates for sale (Dewi et al 2018).

Batu Bara Regency is one of the regencies in the coastal area of the East Coast of North Sumatra. The area is about 90,496 hectares and is located in the lowlands with an altitude above sea level of 0.5 meters. At this time about 10% of the people make a living as cultivators of blood cockle. Blood cockle cultivation activities in this area began in 1960 but are still simple. In 2014 the production of blood cockle reached 330 tons. In 2015 it reached 336 tons. In 2016 it reached 301 tonnes (SPFFLSO 2018; FSOPR 2021).

Recently, the production of blood cockle cultivation tends to decrease. This is indicated by the higher catches of young blood cockles. Based on our founding in 2022, it shows that about 48% of the catch of blood cockle in Batu Bara Regency is young blood cockle with the price received in the market equal to the price of large mussels, namely Rp. 15,000-20,000/kg, thus encouraging their exploitation (Fauzan et al 2018; FSOPR 2021). The increasing market demand for blood cockles has led to high exploitation of catching shellfish in the wild (Mulya & Jhon 2021). Catching seeds in nature for public consumption makes it difficult for collectors to get consumption sizes.

Catching young blood cockles has an impact on decreasing seed production and in the long term threatens the sustainability of blood cockle production in nature. Efforts to preserve the production of blood cockle catches that have been implemented in other areas are by applying catch size selectivity and setting catchment areas so as to provide opportunities for blood cockle regeneration (Jahangir et al 2014; Efriyeldi & Effendi 2022). However, these two solutions are likely to be rejected/ignored by fishermen on the grounds of faster economic gain or pressure on the necessities of life due to the low quality of welfare of coastal communities (Suwanjarat et al 2009; Chee et al 2011). Therefore we need an alternative management strategy that provides economic benefits to blood cockle cultivators that are suitable for coastal community development. This study aims to analyze the prospects and strategies for sustainable blood cockle cultivation by synergizing land suitability, cultivation technology, seed availability, safety, government policies, and blood cockle marketing.

Material and Method

Time and place. This research was conducted from January to August 2022 with research locations in the coastal areas of Perupuk Village (stations 1 and 2) and Gambus Laut Village (station 3), Lima Puluh Pesisir District, Batubara Regency (Figure 1).

Research methods. This study used a survey method with purposive sampling. Samples were collected from the intertidal zone around the blood cockle cultivation environment. Samples were taken once a month for 8 months of observation in 3 intertidal zones, namely the lower, middle and upper intertidal zones.

Water quality. The main parameters measured in this study were: physical parameters (temperature, brightness and substrate type), chemical parameters (pH, dissolved oxygen - DO, nitrate, ammonia), and biological parameters (plankton, micro and macrobenthos density). Water quality samples were examined at the Laboratory of the Faculty of Agriculture, Asahan University. All gathered data were analyzed descriptively. Measurement of physical and chemical parameters of water refers to the RNSA (2022) procedure.

Plankton species and abundance. The plankton parameters observed were species and abundance. Samples were collected at 3 points for each station by using plankton net number 25. The abundance of plankton was calculated using the Sedwicgk rafter counting method. Samples were examined at the Laboratory of the Faculty of Agriculture, Asahan University.

Abundance of micro and macrobenthos. Micro and macrobenthos samples were taken from each research station at three sampling points. Microbenthos samples were taken using planktonnet, while macrobenthos samples were taken using Ekman drage. Microbenthos samples were preserved with 4% formalin and macrobenthos were preserved with 10% formalin. The samples were identified and their abundance was determined using a dissecting binocular microscope in the laboratory by referring to Panggabean & Romimohtarto (1977), Guglielmo & Ianora (1997), Li & Migliaccio (2010) and Eleftheriou (2013). The identification of microbenthos and macrobenthos was carried out in the laboratory of the Faculty of Agriculture, Asahan University. The abundance of plankton was calculated using the following formula:

$$N = n\ (A/B) \times (C/D) \times (l/p)$$

where: N = abundance of plankton;
n = number of individuals of the 1st species;
A = cover glass area (mm^2);
B = field of view (mm^2);
C = volume of filtered water (mL);
D = volume of water 1 drop (mL);
l = volume of filtered water (liters);
p = total fields of view.

The population density of benthos was calculated by the following formula:

$$\text{Population density of benthos} = \frac{\text{Number of individuals of a genus}}{\text{Sample unit area}}$$

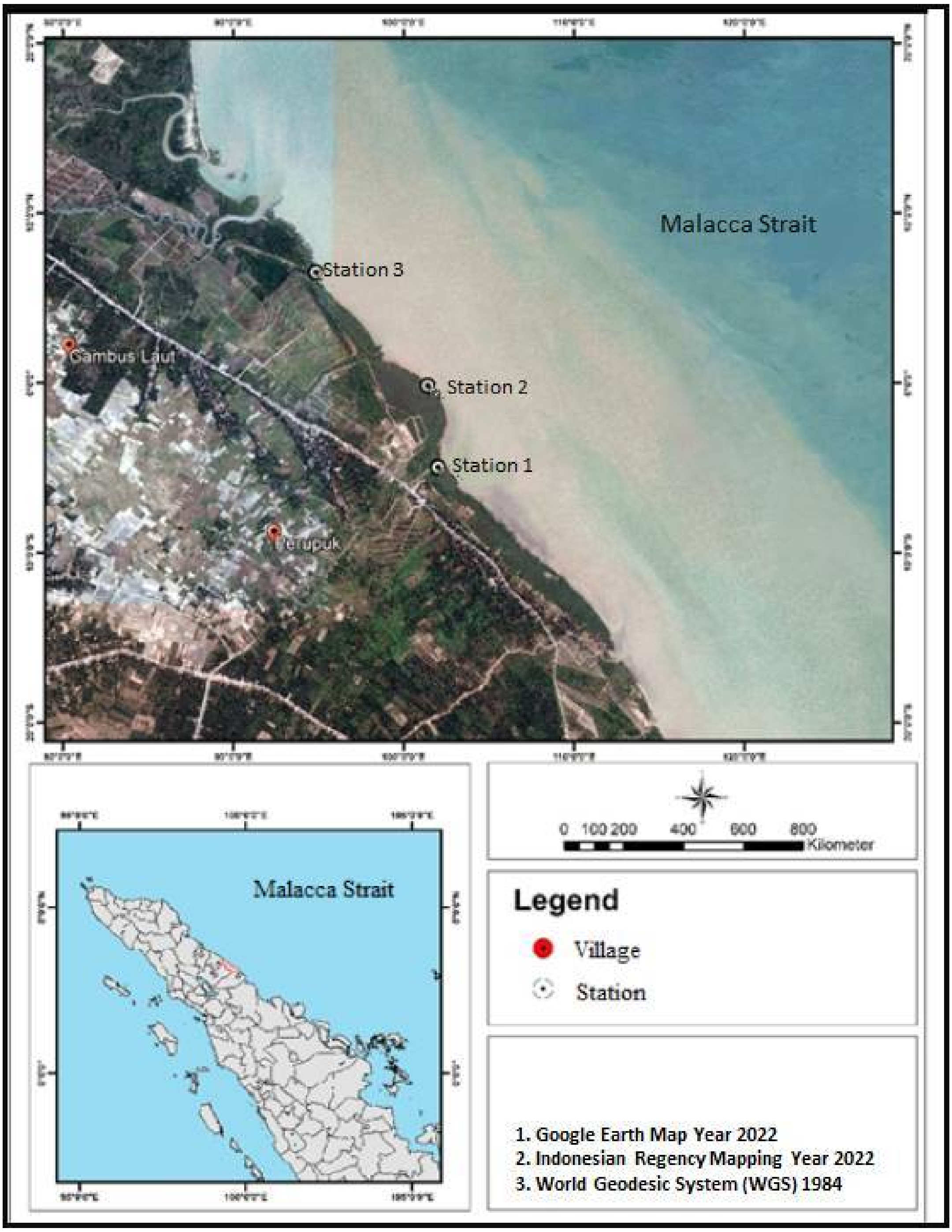

Figure 1. Research location in Lima Puluh Pesisir District, Batu Bara Regency.

Cultivation and development prospect. Data on cultivation activities and analysis of business development prospects were obtained by analyzing all technical data (water quality and biological parameters), observing the location of blood cockle cultivation, and interviews with some cultivators. Information on seed availability, product marketing prospects and government policies was obtained from direct field observations, interviews with cultivators, community leaders and local government.

Result

Cultivation blood cockle. Blood cockle is one of the fishery sector commodities which is expected to develop in Batubara Regency. Of the total 1,630.18 aquaculture production in 2016, 301 tons or 18.46% came from blood cockle production. Blood cockle cultivation is very suitable to be carried out in waters that have a muddy and sloping substrate base (FSOPR 2021). There are many coastal conditions that have such characteristics along the coast of this area.

Blood cockle cultivation in Batu Bara Regency started around 1960. At that time people preferred the business of collecting the cockle seeds and then selling them to Malaysia. Some people catch consumption-sized shellfish and sell them to meet the needs of the local market and several cities in North Sumatra Province (FSOPR 2021). The high demand for cockle consumption has caused cockles that grow naturally in their habitat to be over-exploited. It is getting more and more difficult every day to get a consumption-sized cockle, so even small animals are caught by fishermen. Around 2014, the community tried to cultivate shellfish and it turned out to be a very profitable production. Since then, people have become interested in developing blood cockle cultivation (SPFFLSO 2018; Efriyeldi & Effendi 2022).

The cultivation is spread along the coast of Batu Bara Regency starting from Lima Puluh Pesisir District (Perupuk Village and Gambus Laut Village), Sei Suka District (Kuala Indah Village) and Medang Deras District (Lalang Village). The District of Lima Puluh Pesisir is an area that has the largest blood cockle cultivation pond compared to other districts (Figure 2).

Figure 2. Blood cockle pond area in Perupuk Village, Lima Puluh Pesisir District.

The technology for blood cockle cultivation is carried out by the community using a fence system (fence cockle culture). In coastal areas that have a muddy and sloping base (substrate) a pond plot with varying sizes is made according to the ability of the owner of the pond. The size of the ponds in the upstream of the Lima Puluh Pesisir District starts from the smallest measuring 3 x 4 meters, then 100 x 100 meters and there are even some ponds measuring 200 x 200 meters.

To distinguish between one pond plot and another, a guardrail is made in the form of poles attached to a net around the pond plot. The height of the net is approximately 0.5 meters and the bottom is buried in the mud at the bottom of the pond. This pond fencing serves not only to limit the ownership of the pond, but the most important thing is to act as a barrier so that the blood cockle that are cultivated do not leave the pond plot. After that, the pond is ready to be stocked with seeds and the blood cockle maintenance period begins. During the maintenance period, some pond owners employ 1–2 people to supervise and maintain the ponds. To protect the pond, the owner builds a guard house on his pond plot (Figure 3).

Until now, seeds for blood cockle cultivation in Batu Bara Regency still depend on seeds from nature. Natural seeds are obtained from the waters along the coast around the blood cockle cultivation area. Usually people collect seeds around February to March, so it is predicted that the spawning season will occur around January. The size of the captured seeds varies from the most refined size of granulated sugar, the size of a green pea to the size of a peanut. Blood cockle seeds are purchased from fish traders at various prices. The highest price for a seed size of granulated sugar is IDR 350,000/can. The bigger the size of the seed, the cheaper the selling price. Seeds with the size of green peas are sold for Rp. 150,000/can and the size of peanuts is Rp. 100,000/can.

Figure 3. The guard house for blood cockle cultivation in Gambus Laut Village, Lima Puluh Pesisir District.

At the beginning of the rearing period, the seeds were sown with an initial stocking density of around 2,000 individuals m^{-2} and then spaced up to 200-300 individuals m^{-2}. In a rearing unit, blood cockles have gradually begun to be harvested after 4-5 months of rearing. Total harvesting is done at the end of the 9th month of cultivation. During the maintenance period, entering the 4th and 5th months, blood cockle cultivators began to harvest. Harvesting is done when the water level is about 0.5 meters from the bottom of the pond, so that the harvesting process is easier to do by going down to the pond and dredging the bottom of the pond using a rake. Blood cockle harvesting is carried out by a group of surrounding communities, for example housewives. They are usually paid cheaply, namely Rp. 1,000/kg cockles. The harvest period is an alternative for local people to increase their income. From observations at the site, it can be seen that the community also involves other family members for harvesting (Figure 4).

Figure 4. Harvesting blood cockles (left) and selling the commodity in Lima Puluh Pesisir District (right).

Water quality. Based on the measurement results, the water in the waters of the Lima Puluh Pesisir District showed a salinity of 34 ppt. Water temperature ranged from 28 to 29^{o}C, brightness was 50 to 53 cm, pH was in the range of 8.0-8.2, dissolved oxygen was between 5.2 and 5.4 mg L-1, and alkalinity was between 122 and 125 mg L^{-1} (Table 1).

Table 1

Water quality data in Lima Puluh Pesisir District, Batu Bara Regency

No.	*Parameter*	*Unit*	*Station 1*	*Station 2*	*Station 3*	*Standard**
1	Salinity	ppt	34.0	34.0	34.0	10-35
2	Temperature	^{o}C	28.0	28.8	29.0	28-30
3	Brightness	cm	50.0	52.0	53.00	60
4	pH		8.0	8.1	8.2	7.5-8.5
5	Dissolved oxygen	mg L^{-1}	5.2	5.4	5.2	> 3.0
6	Alkalinity	mg L^{-1}	124	125	122	80-150

* RNSA (2022).

In this study, as many as 30 species of phytoplankton were identified (Table 2). The abundance of phytoplankton of the Bacillariophyceae class was higher at station 1, with a total abundance of 27,556 ind L^{-1} plankton. While at station 2 this number was 18,099 ind L^{-1} and at station 3 it was 14,445 ind L^{-1}.

Table 2

Abundance of phytoplankton Bacillariophyceae (ind L^{-1}) in the waters of the District of Lima Puluh Pesisir

No.	*Taxa*	*Station 1*	*Station 2*	*Station 3*
1	*Asterionella* sp.	345	200	200
2	*Bacillaria paradoxa*	523	390	550
3	*Bacteriastrum* sp.	300	537	451
4	*Bellerochea malleus*	525	487	455
5	*Biddulphia mobiliensis*	327	340	351
6	*Biddulphia sinensis*	210	531	515
7	*Biddulphia* sp.	0	882	341
8	*Chaetoceros* sp.	531	1,250	568
9	*Cocconeis* sp.	901	600	545
10	*Coscinodiscus* sp.	10,467	2,684	920

11	*Diploneis* sp.	360	180	0
12	*Ditylum brigthwellii*	365	145	160
13	*Fragilaria cylindrus*	355	543	548
14	*Fragilaria oceanica*	360	322	200
15	*Fragilaria* sp.	1,253	895	1,432
16	*Hemiaulus indicus*	358	355	256
17	*Hemiaulus sinensis*	567	400	257
18	*Hemiaulus* sp.	358	342	400
19	*Leptocylindrus danicus*	567	550	358
20	*Melosira* sp.	3,421	895	2,100
21	*Nitzschia* sp.	540	1,253	0
22	*Pleurosigma* sp.	1,890	767	456
23	*Rhizosolenia alata*	378	222	400
24	*Streptotheca indica*	24	65	537
25	*Streptotheca* sp.	0	900	541
26	*Thalassiothrix frauenfeldii*	375	302	200
27	*Thalassiothrix longissima*	900	867	358
28	*Thalassiothrix* sp.	600	567	560
29	*Triceratium reticulum*	156	180	250
30	*Triceratium* sp.	600	358	556
	Total	27,556	18,009	14,465

There were 3 genera of the Crustaceae zooplankton population, namely *Calanus* sp., *Eurytemora* sp., and *Penaeus* sp. (Table 3). The highest abundance of zooplankton was found at station 1 (2,889 ind L^{-1}), followed by station 2 (2,306 ind L^{-1}) and station 3 (2,002 ind L^{-1}).

Table 3

Abundance of Crustaceae (ind L^{-1}) zooplankton in the waters of Lima Puluh Pesisir District

No.	*Taxa*	*Station 1*	*Station 2*	*Station 3*
1	*Calanus* sp.	1450	887	546
2	*Eurytemora* sp.	787	654	804
3	*Penaeus* sp.	652	765	652
	Total	2,889	2,306	2,002

From the Protozoa zooplankton group we found 5 taxa, namely *Favella* sp., *Globigerina* sp., *Tintinnopsis gracilis*, *Tintinnopsis butchlii*, and *Tintinnopsis* sp. (Table 4). The highest abundance was found at station 1 (3,044 ind L^{-1}), followed by station 2 (2,655 ind L^{-1}) and station 3 each (2,480 ind L^{-1}).

Table 4

The abundance of Protozoa zooplankton (ind L^{-1}) in the waters of the Lima Puluh Pesisir District

No.	*Taxa*	*Station 1*	*Station 2*	*Station 3*
1	*Favella* sp.	426	424	221
2	*Globigerina* sp.	190	600	345
3	*Tintinnopsis gracilis*	224	243	358
4	*Tintinnopsis buetschlii*	600	400	456
5	*Tintinnopsis* sp.	1,604	988	1100
	Total	3,044	2,655	2,480

The zooplankton analysis of the Rotifers group found 3 genera, namely *Brachionus* sp., *Notholca* sp., and *Synchaeta* sp. (Table 5). The abundance of stations 1, 2 and 3, respectively, was 1,753, 1,564, and 1,453 ind L^{-1}.

Table 5
The abundance of Rotifers zooplankton (ind L^{-1}) in the waters of the Lima Puluh Pesisir District

No.	*Taxa*	*Station 1*	*Station 2*	*Station 3*
1	*Brachionus* sp.	788	346	432
2	*Notholca* sp.	544	675	334
3	*Synchaeta* sp.	421	543	687
	Total	1,753	1,564	1,453

From the existing species data and the abundance of indicator organisms tested, it can be interpreted that the water conditions of the Lima Puluh Pesisir District are still classified as good and balanced where the diversity of plankton species is classified as moderate and experiencing light pressure. This is presumably because station 1 is in the middle of the waters (blood cockle cultivation location) so that plankton is found a lot. While at station 2 (located at the end of the river and more influenced by fresh water) the abundance of plankton was lower. The results of the analysis of plankton in different locations showed that the waters provided enough food for blood cockles.

Benthos. Benthos are organisms that attach to or rest on the bottom of the water or on the surface of the bottom substrate of the water. Benthos are aquatic organisms, both in the form of animals and plants, both living on the surface of the bottom or on the bottom of the water. Benthic fauna community (zoo-benthos) live in mud, sand, rocks, gravel, and organic waste at the bottom of the sea, creeping, settling, sticking, burying, and burrowing at the bottom of the waters. In aquaculture activities, the presence of benthos can support the growth of fish, shrimp and shellfish because it can function as natural food for aquaculture organisms. The results of the analysis of the bottom substrate in the waters of the Lima Puluh Pesisir District found 2 important benthic genera, namely *Anadara* sp. and *Corbicula* sp. (Table 6).

Table 6
Analysis of abundance (individual m^{-2}) of macrozoobenthos in the waters of the District of Lima Puluh Pesisir

No.	*Taxa*	*Station 1*	*Station 2*	*Station 3*
1	*Anadara* sp.	321	307	322
2	*Corbicula* sp.	432	372	254
	Total	753	679	576

Blood cockle seeds. Seeds for blood cockle cultivation in Batu Bara Regency still depend on seeds from nature. Natural seeds are obtained from the waters along the coast around the blood cockle cultivation area. Usually people collect seeds around February to March, so it is predicted that the spawning season will occur around January. The size of the captured seeds varies from the most refined the size of granulated sugar, the size of a green pea to the size of a peanut. Blood cockle seeds are purchased from fish collectors at various prices. The highest price for a seed size of granulated sugar is IDR 350,000/can of 18 kg. The bigger the size of the seed, the cheaper the selling price. Seeds the size of green bean seeds are sold for Rp. 150,000/can and the size of peanuts is Rp. 100,000/can.

At the beginning of the rearing period, seed was spread with an initial stocking density of about 2,000 seeds m^{-2} and then spaced up to 200-300 seeds m^{-2}. Blood cockles are harvested after a maintenance period of 4-5 months and ends around the 9th month. Entering the 4th and 5th months, cultivators begin to harvest. Harvesting is done when the water level is about 0.5 meters from the bottom of the pond, so that the harvesting process is easier to do by going down to the pond and dredging the bottom of the pond using a rake. Harvesting is done by a special community by paying a wage of IDR 1,000/kg. From observations at the location, it can be seen that the community also involves other family members for harvesting.

***Commodity marketing prospect*.** Consumer demand for blood cockle commodity continues to increase and can never be fulfilled. The harvested blood cockles are then collected, weighed and sold to collectors for sale to local, regional and export markets. The size of the shells harvested varied from the largest > 4 cm to the smallest size 1-1.5 cm. The selling price of blood cockle in the local market (Batu Bara Regency) is around Rp. 8,500/kg, while if it is sold to Medan, North Sumatra, the price level is better, reaching Rp. 25,000/kg. Meanwhile, blood cockle sold for export to Malaysia has a selling price of around Rp. 20,000/kg with a size requirement of about 3-5 cm or a size of 120 individuals/kg. Blood cockles exported to Malaysia are usually shipped in the form of shellfish that have been peeled and boiled. The job of separating the shells from the contents of the shells is carried out by housewives with a wage of Rp. 3000/kg.

***Local government policy*.** Batu Bara Regency has potential in the marine and fisheries sector with a long coastline of 62 km which stretches in 6 (six) coastal districts with a total of 25,497 fishing households, consisting of fishermen, fish cultivators and household scale fish processing entrepreneurs. The potential for aquaculture is 5,277 hectares, consisting of 4,030 hectares of brackish water cultivation and 1,247 hectares of fresh water cultivation. The Strategic Plan of the Fisheries and Livestock Services Office of Batu Bara Regency for 2019-2023 contains objectives, targets, strategies, policies, programs and activities as well as targets to be achieved related to the aquaculture sector (SPFFLSO 2018). By referring to Indonesia's national policies, the main focus of the Batu Bara Regency government is optimizing the potential of independent and sustainable marine and fisheries resources so that they can become the driving force of the community's economy.

In the Strategic Plan of the Batu Bara Regency Government, some locations have been reserved as blood cockle cultivation areas. These areas include the District of Fifty Pesisir (Perupuk Village and Gambus Laut Village), Seisuka District (Kuala Indah Village) and Medang Deras District (Lalang Village). The location determination is also followed by the provision of a budget for training and development of activities for blood cockle farmers. In addition, several locations are planned to become special areas to be protected from fishing and cockles catching areas. This effort is intended to provide space and time for the blood cockle population to breed and provide a natural source of seeds and broodstock.

Discussion. *Anadara* sp. is one of the bivalves that are cultivated in the waters of the Lima Puluh Pesisir District. This animal grows and develops well and the demand is quite high, so many people are interested in keeping it. The maintenance of the blood cockle is carried out along the coast of the Lima Puluh Pesisir District. This biota lives in coastal waters that have muddy sand and can also be found in estuary, mangrove and seagrass ecosystems. It lives in groups, being generally found on substrates rich in organic content (Praja et al 2014; Theerachat et al 2020).

The intertidal area is an area located at the very edge of the coastal and marine ecosystems bordering the land ecosystem. Intertidal is a tidal area that is influenced by coastal and marine activities. Tidal conditions do not change much except in certain extreme conditions that can change the composition and abundance of intertidal organisms. This area is an area that has a relatively higher diversity and abundance of organisms compared to other marine habitats. Perupuk Village and Gambus Laut Village are villages in the District of Lima Puluh Pesisir, Batu Bara Regency which have coastal ecosystems that are influenced by the daily cycle of sea tides (SPFFLSO 2018; Riza et al 2021).

The length of the coastline of Batu Bara Regency is 62 km, the beach is relatively sloping and muddy and bears relatively weak, and is directly adjacent to the Malacca Strait. This condition makes this area having a large enough potential for fisheries, both capture fisheries, aquaculture and fishery product processing. The fishery potential consists of brackish water, sea water and fresh water aquaculture fisheries. According to the Batu Bara Regency fishery statistics in 2019, the potential for brackish water aquaculture is 4,030 ha, freshwater aquaculture is 1,247 ha and seawater aquaculture is

330 ha (FSOPR 2021; CBS 2022) in Batu Bara Regency.

The blood cockle cultivation business is feasible to be developed in Batu Bara Regency, both based on financial and non-financial analysis. From the financial aspect, it shows that the blood cockle cultivation business can be implemented on a small scale using own capital, and can be run with loan capital. Likewise, from the non-financial aspect, fishermen showed a positive response to blood cockle cultivation and in general fishermen considered this business to be cheap, easy and profitable. This blood cockle cultivation effort is expected to be a source of additional income that can increase fishermen's income, while preserving blood cockle production in nature (Yulinda et al 2020).

Seeds for blood cockle cultivation in Batu Bara Regency still depend on seeds from nature. Natural seeds are obtained from the waters along the coast around the blood cockle cultivation area. Availability of seeds is one of the problems of blood cockle cultivation in this area. Seeds caught from nature are actually starting to become insufficient. In addition, these seeds are also not available throughout the year. This lack of seeds can trigger overfishing of seeds, and even damage the bottom ecosystem of the waters where the next generation of seeds is grown (Wong & Lim 1985; Saffian et al 2020). Uncontrolled blood cockle catching threatens the sustainability of the production of this commodity. This is indicated by the high number of young blood cockle catches. Therefore, it is important to formulate a management strategy that can provide opportunities for blood cockles to spawn in nature before being used, namely through the integration of cultivation efforts and existing fishing efforts. The function of blood cockle cultivation is to maintain small blood cockle catches, thus providing an opportunity for blood cockles to spawn in nature before being used, namely through the integration of cultivation efforts and existing fishing efforts (Piumsombun et al 2005; Riza et al 2021).

Blood cockle production is not always stable throughout the year. It fluctuates according to weather conditions which affect their growth and reproduction in nature. But on the other hand, consumer demand for this commodity continues to increase and can never be fulfilled. The harvested blood cockles are then collected, weighed and sold to collectors for sale to local, regional and export markets. From an economic point of view, it can be said that the blood cockle cultivation business in Batu Bara Regency is a very prospective business. This is because the business capital required is relatively small but with promising benefits. This is consistent with Nurdin et al (2006), Suwarjarat et al (2009), Yang et al (2016). There is still potential land for blood cockle cultivation in the future. This is an opportunity for local traditional fishermen to increase their income, because they are no longer dependent on the season. Marketing of shellfish commodities to Malaysia is an opportunity itself. Despite sufficient domestic demand, this product can also be easily exported to Malaysia via Port Klang (Yulinda et al 2020).

The Strategic Plan of the Batu Bara Regency Government has reserved several locations as areas for blood cockle cultivation. These areas include the District of Fifty Pesisir (Perupuk Village and Gambus Laut Village), Seisuka District (Kuala Indah Village) and Medang Deras District (Lalang Village). This policy clearly supports the development program for blood cockle cultivation in this area. The development of a development effort that involves many people and requires a large area of land should be in line with local government policies. Some of the positive values of this government policy support include: the allocation of initial funds for business development, prevention and protection of environmental damage from the government, the establishment of a conducive spatial layout and assistance for cultivation technology needed (Agboola & Braimoh 2009; Santoso et al 2015).

Conclusions. Physical parameters of water quality (temperature, brightness and substrate type), chemical parameters (pH, DO, nitrate, ammonia), and habitat biological parameters (micro and macrobenthos density) indicated that blood cockle is feasible to develop in Batu Bara Regency. The market potential for blood cockle commodity is wide open (local, national and international), cultivation technology can be developed, the location is relatively safe and supported by government policies. The main obstacle is the availability of natural seeds which are increasingly difficult to obtain. Solutions that can be taken include the use of hatcheries and the establishment of protected areas as natural hatchery areas.

Acknowledgements. We would like to thank the Directorate General of Higher Education, Ministry of Education and Culture of the Republic of Indonesia for funding this research through the Institute for Research and Community Service, Riau University, Pekanbaru, Indonesia.

Conflict of interest. The authors declare that there is no conflict of interest.

References

Agboola J. I., Braimoh A. K., 2009 Strategic partnership for sustainable management of aquatic resources. Water Resources Management 23(13):2761-2775.

CBS (Central Bureau of Statistic) of Batu Bara Regency, 2022 [Batu Bara Regency in figures]. Central Bureau of Statistic of Batu Bara Regency, Batu Bara, 580 pp. [in Indonesian]

Chee S. Y., Azizah M. N. S., Devakie M. N., 2011 Utilization of molecular markers for the conservation of blood cockles, *Anadara granosa* (Arcidae). Genetics and Molecular Research 10(2):1245-1261.

Dewi S. E., Eddiwan E., Efawani E., 2018 [Morphometric and growth patterns of the blood clam (*Anadara granosa*) from the Bagan Siapi-Api coastal area Rokan Hilir]. Berkala Perikanan Terubuk 46(3):37-45. [in Indonesian]

Efriyeldi E., Effendi I., 2022 Aspects of reproduction biology of blood cockle (*Anadara granosa*) in Pasir Limau Kapas waters. AACL Bioflux 15(4):1648-1655.

Eleftheriou A. (ed), 2013 Methods for the study of marine benthos. 4th edition. Wiley-Blackwell, 496 pp.

Fauzan M., Bakti D., Susetya I. E., Desrita, 2018 Growth and exploitation rate of *Anadara gubernaculum* (Reeve, 1844) Arcidae family in Asahan Aquatic of North Sumatra. IOP Conference Series: Earth and Environmental Science 122:012105.

FSOPR (Fisheries Service Office Performance Report) of Batu Bara Regency, 2021 [The Fisheries Office Service of Batu Bara Regency]. Batu Bara, 52 pp. [in Indonesian]

Guglielmo L., Ianora A. (eds), 1997 Atlas of marine zooplankton Straits of Magellan. Amphipods, Euphausiids, Mysids, Ostracods, and Chaetognaths. Springer, 263 pp.

Jahangir S., Siddiqui G., Ayub Z., 2014 Temporal variation in the reproductive pattern of blood cockle *Anadara antiquata* from Pakistan (northern Arabian Sea). Turkish Journal of Zoology 38(3):263-272.

Khalil M., Yasin Z., Hwai T. S., 2017 Reproductive biology of blood cockle *Anadara granosa* (Bivalvia: Arcidae) in the northern region of the Strait of Malacca. Ocean Science Journal 52(1):75-89.

Li Y., Migliaccio K. (eds), 2010 Water quality concepts sampling and analyses. CRC Press, Boca Raton, 344 pp.

Mulya M. B., Jhon A. H., 2021 Study of *Anadara antiquata* stock in Kuala Puteri Beach, North Sumatra. AACL Bioflux 14(6):3547-3555.

Nurdin J., Marusin N., Izmiarti, Asmara A., Deswanti R., Marzuki J., 2006 [Population density and growth of blood cockles *Anadara antiquata* L. Pelecypoda in Pisang River Bay, Padang City, West Sumatra]. Journal of Makara Science 10(2):96-101. [in Indonesian]

Panggabean L. M. G., Romimohtarto K., 1977 Status of the identification of larvae of bivalve molluscs in Indonesia. Phuket Marine Biological Center Special Publication 17(2):343-348.

Piumsombun S., Rab M. A., Dey M. M., Srichantuk N., 2005 The farming practices and economics of aquaculture in Thailand. Aquaculture Economics and Management 9(1-2):265-287.

Praja F., Rusliadi R., Mulyadi M., 2014 [Growth rates of shellfish blood (*Anadara granosa*) at different stocking density]. Jurnal Online Mahasiswa 1(1):821-822. [in Indonesian]

Riza S., Gevisioner G., Suprijanto J., Widowati I., Putra I., Effendi I., 2021 Farming and food safety analysis of blood cockles (*Anadara granosa*) from Rokan Hilir, Riau, Indonesia. AACL Bioflux 14(2):804-812.
RNSA (Regulation of the National Standardization Agency) of the Republic of Indonesia No. 4 of 2022 concerning Amendments to Regulation of the National Standardization Agency of the Republic of Indonesia Number 4 of 2021 concerning the Conformity Assessment Scheme of Indonesian National Standards in the Agriculture, Plantation, Livestock and Fisheries Sector. National Standardization Agency of the Republic of Indonesia, Jakarta. [in Indonesian]
Saffian N. S., Peng C. T. C., Ilias N., Hwai A. T. S., 2020 Overview and challenges of blood cockle culture in Malaysia. IOP Conference Series: Earth and Environmental Science 414:012020.
Santoso P., Marsoedi, Maftuch, Susilo E., 2015 Building strategy priority of blood cockle aquaculture development for conservation and welfare in sub-district of Central Kupang, West Timor, Indonesia. Journal of Biodiversity and Environmental Sciences 7(4):34-42.
SPFFLSO (Strategic Plan of Fisheries and Livestock Service Office) of Batu Bara Regency 2019-2023. 2018 [The Fisheries and Livestock Service Office of Batu Bara Regency]. Batu Bara, 55 pp. [in Indonesian]
Suwanjarat J., Pituksalee C., Thongchai S., 2009 Reproductive cycle of *Anadara granosa* at Pattani Bay and its relationship with metal concentrations in the sediments. Songklanakarin Journal of Science and Technology 31(5):471-479.
Theerachat M., Glinwong C., Chulalaksananukul W., 2020 Dataset of blood cockle (*Anadara granosa*) microbiota from coastal areas and earthen-pond farms around the upper Gulf of Thailand. Data in Brief 30:105393.
Triatmaja R. A., Pursetyo K. T., Triastuti J., 2019 The density of blood cockle (*Tegillarca granosa*) population in the river estuary of industrial area. AACL Bioflux 12(4): 1025-1030.
Wong T. M., Lim T. G., 1985 Cockle *Anadara granosa* seed produced in the laboratory, Malaysia. ICLARM Newsletter 8(4):13.
Yang H., Sturmer L. N., Barker S., 2016 Molluscan shellfish aquaculture and production. Electronic Data Information Source, FA191. Gainesville, Florida, USA: University of Florida, 8 pp.
Yulinda E., Saad M., Yusuf M., 2020 A study on the economic potential of blood cockles (*Anadara granosa*) in Rokan Hilir, Riau Province, Indonesia. AACL Bioflux 13(3): 1504-1510.

Received: 14 January 2023. Accepted: 18 March 2023. Published online: 07 June 2023.
Authors:
Azizah Mahary, Faculty of Agriculture, University of Asahan, Kisaran, Indonesia, e-mail: azizah.mahary@yahoo.com
Irwan Effendi, Faculty of Fisheries and Marine Sciences, University of Riau, Pekanbaru 28295, Indonesia, e-mail: helpingirwan@gmal.com
Hendrik Hendrik, Faculty of Fisheries and Marine Sciences, University of Riau, Pekanbaru 28295, Indonesia, e-mail: hendrik@lecturer.unri.ac.id
Darwis Darwis, Faculty of Fisheries and Marine Sciences, University of Riau, Pekanbaru 28295, Indonesia, e-mail: darwis@unri.ac.id

How to cite this article:
Mahary A., Effendi I., Hendrik H., Darwis D., 2023 Strategy for development of blood cockles (*Anadara granosa*) cultivation in Batubara Regency, North Sumatera, Indonesia. AACL Bioflux 16(3):1636-1647.