Analysis of environmental quality, production performance and economic feasibility of *Anadara granosa* cultivation in Sukal, Bangka Belitung Province

[1,2]Eva Prasetiyono, [1]Kukuh Nirmala, [1]Eddy Supriyono, [1]Sukenda, [1]Yuni P. Hastuti

[1] Department of Aquaculture, Faculty of Fisheries and Marine Science, Bogor Agricultural University, Bogor-West Java, Indonesia; [2] Department of Aquaculture, Faculty of Agriculture, Fisheries and Biology, Bangka Belitung University, Indonesia. Corresponding author: K. Nirmala, kukuhni@apps.ipb.ac.id

Abstract. Blood cockles (*Anadara granosa*) cultivation is one of the efforts to utilize coastal waters. Bangka Belitung, one of the provinces in Indonesia, has blood cockles cultivation center on the Sukal coastal waters, preserved from tin mining activities. The cultivation carried out by the local community needs to be analyzed for environmental support, productivity, and economic feasibility to ensure further development. Therefore, this study aimed to analyze the environmental characteristics, production performance, and financial feasibility of blood cockles aquaculture in Sukal coastal waters, Bangka Belitung Province. Environmental quality data were obtained through measurement, substrate type, and water quality analysis at the site. Meanwhile, data on the production and financing of business activities were obtained from the blood cockles cultivators' respondents. The results showed that the substrate type was soft mud. The salinity, temperature, pH, and dissolved oxygen values were 25-29 ‰, 29-30^{o}C, 7.4-7.9, and 5.8-6.3 mg L^{-1}, respectively. The values of revenue, profit, payback period (PP), break-even point of production (BEP production), break-even point of price (BEP price), revenue of cost ratio (R/C ratio), and benefit of cost ratio (B/C ratio) for a land area of 5,000 m^2 were IDR 87,750,000, IDR 69,620,000, 3.6 months, 1,394.62 kg, IDR 2,685.93, 4.84, and 3.84, respectively. Furthermore, the activities in the Sukal coastal waters had environmental characteristics suitable for blood cockles cultivation. It could increase land productivity and was profitable with all the positive benefits. The prospect of developing this activity was very high and sustainable. Therefore, it should be defended from destructive activities, specifically tin mining.

Key Words: blood cockles, financial feasibility, production performance, Sukal coastal waters.

Introduction. Indonesia is an archipelagic country that has an area with a coastline of 95,161 km (Suryana & Amalia 2021). Coastal waters offer a habitat for a variety of aquatic organisms. These habitats include mangroves and shallow seas to cultivate blood cockle, *Anadara granosa*, which is a soft substrate-dwelling bivalve species that can live independently in an ever-changing environment (Arapov et al 2010). These animals can also live in coastal parts of shallow seas, specifically littoral or sandy bottom areas. The species are native to the intertidal mudflats of many Southeast Asian countries, particularly Indonesia, Malaysia, and Thailand. Blood cockles are mainly distributed in mangroves, muddy vegetation, and mixed areas (Khalil et al 2017). The growth is influenced by several factors, including season, temperature, food, salinity, and other water chemistry factors, which vary in each region (Riniatsih & Wibowo 2010). As benthic and infauna organisms, they live on the bottom of the waters, highly dependent on substrate presence. The substrate can determine the distribution, abundance, living habits, and environmental parameters (Arapov et al 2010). Furthermore, environmental pressures that cause changes in the physical, chemical, and substrate biological composition can cause interference with the cultivation (Nicholausa et al 2019).

Blood cockles are marine commodities with potential and high economic value. The nutritional value of these organisms as the protein and minerals source is very high. The meat contains fat, glycogen, omega-3, and vitamins (Riza et al 2021). Therefore, the commodity is economically essential to meet people's food requirements (Salaenoi et al 2015). Efforts to obtain blood cockles are mostly made through fishing activities by fishermen. The cultivation is useful for rearing chicks caught by fishermen to obtain optimal growth and breeding before marketing. Therefore, it can allow regeneration in the wild to restock the blood cockles population. Fishing communities can benefit economically from catches and aquaculture production (Santoso et al 2015).

The fishery and marine resource utilization in Bangka Belitung Province is one of the regional development priorities. This is supported by the area's geographical conditions, which have sea waters four times wider than the mainland. The marine is 65,301 km^2 or 79.90% of Bangka Belitung, and the land area is 16,424.06 km^2 or 20.10% of the total (BPS 2022). The Provincial Government has designated Sukal coastal waters as a blood cockles cultivation area because the water conditions support the business development. The cultivation in 2020 reached a production yield of 485.3 tons with a production value of IDR 4,367 million (KKP 2020).

Sukal coastal waters are inhabited by mangrove plants and sandy mud substrate. This makes the waters as the location for blood cockles cultivation by the local community. Furthermore, 90% of the Sukal hamlet community directly adjacent to the coastal waters, cultivates this species, with fishermen's main livelihood, and the activities have been carried out for generations. The location is a center for blood cockles cultivation in Bangka Belitung, and these waters are still safe from tin mining activities at sea.

Most Bangka Belitung marine areas are tin mining locations (Ibrahim et al 2022). The activity causes damage to fishery potential and decreases fishermen's seawater quality and catches (Ibrahim et al 2018). Even though the activities are seen as impacting people's income and economy, they cause aquatic ecosystem degradation and land displacement for fishing activities. The local community's wisdom prohibits tin mining activities in the Sukal coastal waters so that these locations remain a center for blood cockle cultivation. This is because the cultivation utilizing natural waters is an aquaculture activity that can provide benefits. It is environmentally friendly, and sustainable. The productivity and feasibility need to be assessed in supporting the community's development of activities. Therefore, this study analyzes the environmental characteristics, production performance, and economic feasibility of cultivation on the Sukal coast waters, Bangka Belitung Province. The results are expected to provide the environmental feasibility overview and the prospective business of activities carried out by the Sukal coastal community, Belo Laut Village, West Bangka Regency, Bangka Belitung Province.

Material and Method

Description of the study sites. This study was conducted from July to September 2022 in the Sukal coast, Belo Laut Village, Mentok District, West Bangka Regency, Bangka Belitung Province, Indonesia.

Data and method. The environmental quality of blood cockle culture consists of water quality and sediment quality. Water quality data were collected directly by testing parameters at the cultivation site (in situ). The sediment substrate quality was measured by taking samples from the field. Their test was repeated three times, and the three sampling stations were selected with the following criteria: i) station 1: around the shellfish cultivation area, located around the mouth of the river (2°07'35.3" S 105°20'47.2" E); ii) station 2: the mussel culture area which is an active production area for shellfish (2°07'35.7" S 105°20'47.4" E); and iii) station 3: the shellfish cultivation area near the sea (2°07'43.0" S 105°20'53.0" E) (Figure 1). Furthermore, data from the three stations ranged from the lowest to the highest value.

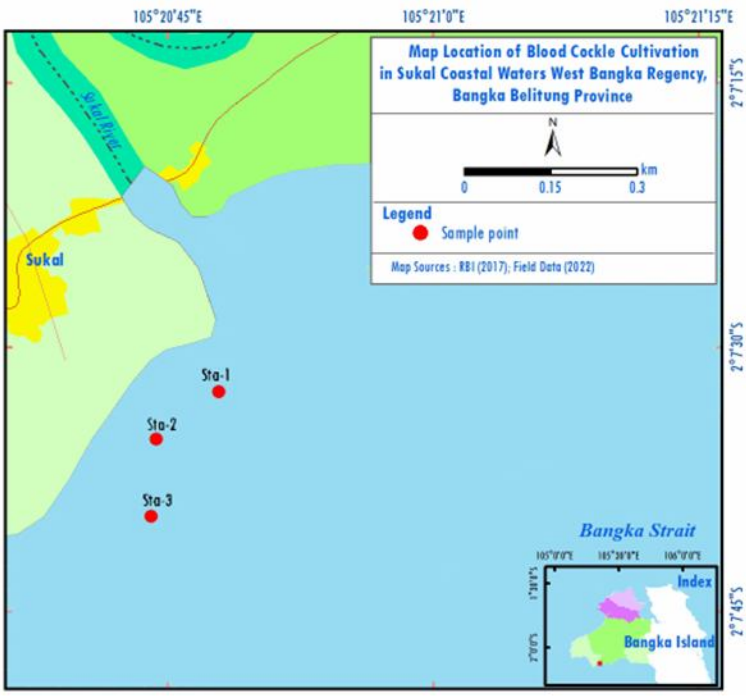

Figure 1. Location of environmental quality measurement stations in the blood cockle cultivation area in Sukal coastal waters.

Information was collected to obtain data on production and financial activities using an instrumentation survey method (Ponto 2015). Instrumentation was conducted using questionnaires and interviews with blood cockles cultivators. The population in this coastal area is 110 cultivators, and the respondents used as samples were 22 people based on the slovin method. The slovin formula used is as follows (Sevilla et al 2007):

$$n = \frac{N}{1 + Ne^2}$$

where: n = number of respondents sample;
N = total population (110 cultivators);
e = error tolerance limit (20%).

Environmental quality analysis. The environmental quality parameters measured were blood cockles sediment substrate type, temperature, pH, oxygen, and salinity. The substrate type was analyzed using substrate samples based on Rifardi (2008). In addition, salinity, temperature, pH, and dissolved oxygen were measured using a hand Refractometer ATC-S/Mill-E Atago, digital thermometer TP101, PH Meter Hanna Digital HI 98107, and DO meter portable DO-66, respectively. The measurement data were compared with the literature on the natural habitat conditions of blood cockles.

Production performance analysis. The total production, productivity, and viability variables were calculated to analyze the performance. Total production was calculated from the biomass of blood cockles harvested. Productivity is calculated from total production per unit area (Diatin et al 2021). Several components were considered for production performance, namely the overall biomass weight of the blood cockles at the beginning of stocking and the end of rearing viability. Furthermore, the number of blood cockles in the cultivation area at the end of maintenance, the cultivation length, and the cycle were also considered.

Economic feasibility analysis. The cost structure calculation and the financial feasibility analysis include investment costs, fixed costs, variable costs, total costs, total income, profits, profit margins, payback period, revenue of cost ratio, break-even point of production (BEP production), break-even point price (BEP price), and benefit of cost ratio (B/C ratio). Some of the formulas used can be seen in Table 1.

Table 1

Financial feasibility analysis formulae

Formula	*Description of notation letter*	*Criteria*	*Reference*
TC = TFC + TVC	TC = total cost (IDR) TFC = total fixed cost (IDR) TVC = total variable cost (IDR)	Lower, better	*)
TR = Q x P	TR = total revenue (IDR) Q = total production (kg) P = price (IDR/kg)	Higher, better	*)
Pt = TR – TC	Pt = profit (IDR) TR = total revenue (IDR) TC = total cost (IDR)	Higher, better	*)
PM = $\frac{Pt}{TR} x\ 100\%$	PM = profit margin (%) Pt = profit (IDR) TR = total revenue (IDR)	Higher, better	*)
PP = $\frac{I}{pt} x\ 1\ year$	PP = payback period (year) I = investment (IDR) Pt = profit (IDR)	PP < 5 years means that the business has a fast and feasible PP; PP > 5 years means the business has slow PP and is not feasible to operate	*)
R/C ratio = $\frac{TR}{TC}$	R/C ratio = revenue of cost ratio TR = total income (IDR) TC = total cost (IDR)	R/C ratio > 1, cultivation is feasible and profitable; R/C ratio = 1, break-even cultivation business; R/C ratio < 1, cultivation is not feasible or detrimental	*)
BEP unit = $\frac{TC}{P}$	BEP unit = production break-even point (kg) TC = total cost (IDR) P = selling price per kg (IDR)	Lower, better	**)
BEP price = $\frac{TC}{TP}$	BEP price = break-even point price (IDR) TC = total cost (IDR) TP = total production (kg)	Lower, better	**)
B/C ratio = $\frac{Bt}{TC}$	B/C ratio = benefit of cost ratio Bt = benefit (IDR) TC = total cost (IDR)	B/C ratio > 1, cultivation is feasible and profitable; B/C ratio = 1, break-even cultivation business; B/C ratio < 1, cultivation is not feasible or detrimental	***)

Notes: *) Diatin et al (2020); **) Kumar et al (2018); ***) Hernandez-Llamas & Herzberg (2011).

Data analysis*.* Quantitative data obtained from this study were tabulated using Microsoft Office Excel 2019. Furthermore, the data were analyzed descriptively by explaining the meaning of the values obtained.

Result and Discussion

Description of blood cockles cultivation activities at Sukal coastal waters*.* Sukal coastal waters are directly adjacent to Sukal, Belo Laut Village, Mentok District, West Bangka Regency, and the ecosystem is protected from tin mining activities. These waters are shallowly overgrown with low-density mangrove vegetation and lined up along the coast. The estuary area close to these waters is the location for blood cockles cultivation. Furthermore, the cultivation activities are carried out by almost all family heads of Sukal hamlet. The entire community can use the land without buying or renting, and blood cockles cultivation has been carried out for decades. According to Dalmiyatun et al (2018), the activities can be performed from generation to generation from the family. Farmers gain knowledge from learning by relying on their business experience.

The community conducts blood cockles cultivation activities traditionally using a pen culture system (Figure 2). This system is cages with various shapes and sizes that can be made from materials that involve holding cultured biota for the short or long term. It is stationary, as well as has fixed walls and some effective permeable barricades (nylon nets, nets) where cultured biota cannot escape the retaining wall (Chandra et al 2013). The cultivation activity begins with land preparation and the pond nets' installation as a cage for holding blood cockles with an installed height of 40-50 cm. The blood cockles distribution from the waters around the location was also conducted. Seedlings were purchased for IDR 3,000 per kilogram with a size of 0.5-1 cm and harvested at a size of 1.5-2.5 cm. Most people use an area of 5,000 m^2 for the cultivation of blood cockles. After the blood cockles are stocked, the maintenance process is performed by controlling the presence. The species carried away by the current were moved and spread out in the middle of the field. Meanwhile, no artificial feed was given because the blood cockles consume natural food. They can feed on plankton, suspended particles, and detritus, with microalgae (phytoplankton) as the leading food (Yurimoto et al 2014). After six months of rearing, harvesting was conducted in the aquaculture process in Sukal waters. The process was carried out by collecting blood cockles from the mud using hands and a scoop net.

Figure 2. Blood cockles cultivation area in the mangrove vegetation area (left) and control activities for pen culture (right).

Environmental quality analysis*.* Based on the results of environmental quality measurements, the cultivation of blood clams in the Sukal coastal waters shows conditions that are in accordance with the natural habitat of blood clockles. The substrate type, temperature, pH, dissolved oxygen, and salinity are shown in Table 2.

Table 2

Quality of the environment for blood cockles cultivation in Sukal Coastal waters

Parameter	*Measurement results*	*Reference*
Substrate type	Soft mud	Soft mud *)
Salinity	25-29 ‰	13.86-30.88 ‰ **)
Temperature	29-30^{o}C	29.54-32.48^{o}C **)
pH	7.4-7.9	6.57-7.82 **)
Dissolved oxygen	5.8-6.3 mg L^{-1}	4.03-7.39 mg L^{-1} **)

Notes: *) Sulistyaningsih & Arbi (2020); **) Pahri et al (2016).

Based on Table 2, the substrate type found in the Sukal coastal waters is soft mud, which is suitable for the blood cockles' life. The characteristic of mangrove area, which has a soft mud substrate in shallow seawater, is an excellent and suitable place (Khalil et al

2017). The growth will be better on soft muddy substrates than on sandy mud (Sulistyaningsih & Arbi 2020). Water quality parameters consisting of salinity, temperature, pH, and dissolved oxygen show values within the range of growth in the natural habitat. Water quality is influenced by natural factors (temperature, weather, climate) and anthropogenic factors (Mutea et al 2021). The aquatic environment can accept incoming material elements and recover conditions in maintaining water quality. It is within the appropriate range for the blood cockles' life with a high level of sensitivity to salinity. Furthermore, salinity shows the concentration of all salt solutions in water and influences osmotic pressure. It affects the osmose regulation process in all aquatic organisms (Khade & Mane 2012). The weather outside the water body influences the temperature at the location of the water. Seawater temperatures that are too high can cause clams to become weak (Srisunont et al 2020). This is because temperature directly affects the organisms' activities, such as growth and metabolism. The indirect effect is an increase in the accumulation of various chemicals and a decrease in oxygen levels (Mugwanya et al 2022). Dissolved oxygen is an essential parameter in assessing the living conditions of aerobic aquatic biota and other biochemical processes (Boyd & Green 2002). The concentration is influenced by the transfer rate from the atmosphere (flooded or moving water), water temperature, salinity, and biological activity (respiration and photosynthesis) (Boyd & Tucker 1998). In addition, pH is an environmental parameter that affects chemical processes, the biota's physiological functions, and the toxicity of toxic compounds. The range in the estuary and marine ecosystems is 6.0 to 9.0 (Boyd & Green 2002).

Production performance analysis. The production performance of blood cockles culture carried out by the community in Sukal waters with a cultivation area of 5,000 m2 is presented in Table 3. Biomass weight is a reference in stocking density, survival, and yield.

Table 3
Production performance of blood cockles cultivated in Sukal coastal waters with area of 5.000 m^2

Component	*Value*	*Details*
Cultivation time	180 days	Per cultivation cycle
Total cycle	2 times	Per year
Overall weight at the start of maintenance	2,500 kg	Per cultivation cycle
	5,000 kg	Per year
Life sustainability	90%	Per cultivation cycle
Overall weight at the end of maintenance	3,375 kg	Per cultivation cycle
	6,750 kg	Per year
Productivity	1.35 kg	Per square meter

Based on the results, not all blood cockles can live and survive in the cultivation location. Some died from predators, pests, diseases, or environmental pressures or disappeared from cultivated land. This is because they were carried away by currents, or their growth stagnated. The survival rate of blood cockles until harvested is 90%. With a land area of 5,000 m^2, 2,500 kg can be stocked, resulting in a total yield of 3,375 kg for one cycle. One year consists of two cycles, and 5,000 kg of seeds are sown with a yield of 6,750 kg. The yield in each cycle is constant and the resulting productivity value shows that the cultivated land can produce blood cockles of 1.35 kg m^{-2}. Factors that affect the productivity value are seedling size, stocking density, weight ratio of biomass to area of cultivated land, and ratio of harvested weight to initial weight of cultivation. Moreover, the production value is also influenced by the cultivation time length and the slow growth characteristics of blood cockles. Epelbaum et al (2011) stated that size and stocking density affect growth with an impact on the productivity culture. Environmental pressures due to natural and human factors can affect productivity results. According to Tumwesigye et al (2022), water quality is essential for maximizing fishery productivity. The parameters should be within the optimal range to maintain the biota's growth and survival. In blood cockles cultivation, the mud substrate also affects the blood cockles' productivity. Syahira et al (2021) stated that the substrate is critical in cultivation because it is a food source, habitat, shelter, and reproduction place. Sedimentary nutrients can also determine blood cockles cultures' survival rate and development.

Financial analysis. The operational cost structure analysis consisting of fixed and variable costs is shown in Table 4. In a year, the cultivators carry out activities for two cycles, and the goods can only be used for the period. After one year, the items should be replaced and new ones purchased. Furthermore, the fixed costs required include making containers (waring, wood, and rope) and harvesting needs (crop containers, boots, and scoop nets). The variable costs include seed blood cockles and the transporting cost for the harvest.

Table 4

Operational cost structure (in one year) blood cockles cultivation with an area of 5,000 m^2 in Sukal coastal waters

Component		*Value (IDR)*	*Percentage*
Fixed cost	Black net	1,400,000	7.72%
	Wood	500,000	2.76%
	Rope	160,000	0.88%
	Harvest container	120,000	0.66%
	Boots	200,000	1.10%
	Scoop net	150,000	0.83%
Total fixed cost		2,530,000	13.95%
Variable cost	Blood cockles seeds	15,000,000	82.74%
	Transport costs	600,000	3.31%
Total variable cost		15,600,000	86.05%
Total cost		18,130,000	100%

Blood cockles cultivation is carried out using a traditional system whose process does not use intensive technology and artificial feed. The feed used is sourced from natural food. This condition affects fixed and variable costs, and the amount incurred affects the profits of blood cockles cultivation activities. In this study, the fixed and variable cost allocation is 13.95% and 86.05%, respectively. The most significant portion of the costs incurred for the blood cockles seeds purchase was 82.74%. Seeds are an essential component, and Dunham et al (2012) found that the stocking density of seeds determines optimal growth, land efficiency, and crop yields. Variable costs occur in each production period, and Kumar et al (2020) stated that the allocation ranged from 79 to 87%, higher than fixed costs of 13-21%. Aquaculture activities require feed costs as an essential component that affects production and profits (Diatin et al 2020). However, blood cockles cultivation only relies on natural food available in nature. In principle, savings in feed costs can increase fish farming profit (Diatin et al 2020). The consequence of using natural feed is the growth of weight and length which is longer and slower.

The total production and selling price influence the revenue size, and the blood cockles cultivation in Sukal waters, with an area of 5,000 m^2, generates an acceptance value of IDR 87,750,000 (Table 5), and the income earned is relatively constant annually. Changes in revenue will depend on the amount of consumer demand, and it affects the selling price. However, the demand for blood cockles is relatively stable, and the sale of harvested blood cockles is carried out to collectors.

Table 5

Total revenue (in one year) on blood cockles cultivation activities with a land area of 5000 m^2 in Sukal coastal waters

Component	*Value*	*Detail*
Production result	6,750 kg	per year
Selling price	IDR 13,000	per kilogram
Total revenue	IDR 87,750,000	per year

The increase in revenue can be achieved by adjusting the input of production factors to increase production output. However, this condition is primarily determined by production capacity and cultivated land (Lee et al 2022). The results showed that the input, specifically the stocking density applied by the cultivators, was optimal when the stocking density was added without increasing the land area. This shows that the production yield of 6,750 kg with total revenue of IDR 87,750,000 is the optimal result for the production capacity of the land owned and the environmental factors support the blood cockles growth.

Financial feasibility analysis is used as the sustainability indicator of blood cockles cultivation (Table 6). It can also determine the business feasibility status regarding its financial aspects. This needs to be conducted to assess the business activities' sustainability and production process. Additionally, the techniques in the fisheries sector can be essential for developing an environmentally friendly business management model based on sustainable economic values (Ferreira et al 2015).

Table 6

Financial feasibility analysis of blood cockles cultivation with an area of 5,000 m^2 in Sukal coastal waters

Component	*Value*	*Note*
Investation	IDR 17,530,000	
The area used for cultivation	5,000 m^2	The average area of land owned by the cultivators
Total production cost	IDR 18,130,000	
Total revenue	IDR 87,750,000	
Profit in one cycle	IDR 34,810,000	Profit
Profit in one year	IDR 69,620,000	Profit
Profit margin	25.18%	
Payback period (PP)	0.3 years/3.6 months	Fit to operate
Break-even point production (BEP production)	1,394.62 kg	
Break-even point price (BEP price)	IDR 2,685.93	
Revenue of cost ratio (R/C ratio)	4.84	Feasible/profitable
The benefit of cost ratio (B/C ratio)	3.84	Feasible/profitable

The primary investment in cultivation is the construction of containers and blood cockles seeds. Based on the results, the income and the feasibility analysis showed that the blood cockles cultivation business was profitable, and all the profit values obtained were positive. The profit earned is IDR 34,810,000 in one cycle or IDR 69,620,000 in one year. The profits are relatively high when compared with the use of simple production technology inputs. This is under Ondhoro et al (2021) opinion, which stated that productivity and profits are inversely proportional to the inputs level and production technology. The PP calculation value in the cultivation activity is 3.6 months. Therefore, the payback for this venture takes 3.6 months, and when viewed from the return rate on capital, this business is feasible to run. This is because the PP analysis value in this business has a shorter period than the investment age (1 year). The short PP is closely related to the high profits obtained. According to Palupi et al (2021), the faster PP is due to increased profits from the production sale. This activity's BEP production and price values were 1,394.62 kg and IDR 2,685.93, respectively. Therefore, the amount of blood cockles production experienced a BEP when the production reached 1,394.62 kg, and the selling price was IDR 2,685.93 per kg. From the data, the production yield and selling price are 6,750 kg and IDR 13,000, respectively. This business activity is very profitable because it exceeds the BEP. Ukav et al (2019) explained that business activities would benefit when they reached and exceeded the BEP value. Furthermore, the R/C and B/C ratio values were obtained at 4.84 and 3.84, respectively. This value is more than 1, which indicates that the business activity of blood cockles cultivation is profitable and feasible to develop. Cultivation business activities provide very high benefits to improve the economy of the community (Diatin et al 2021).

Based on environmental analysis, production performance, and financial feasibility, the cultivation in Sukal waters is very prospective and profitable as supported by the high selling price. This is in line with the Yulinda et al (2020), which analyzed the economic feasibility in Rokan Hilir, Riau Province. The blood cockles cultivation prospect in Sukal coastal waters is supported by several factors, including good and well-maintained water quality, a simple cultivation system, and high survival rate of blood cockles. The results of blood cockles production will be bought by traders at a relatively stable price and profitable for blood cockles cultivators.

Conclusions. Cultivation of blood cockles in the coastal waters of Sukal is in accordance with the environmental characteristics of blood cockles that live in natural habitats. The cultivation activity can increase land productivity and is financially profitable. The prospect is very high, sustainable, and environmentally friendly. Furthermore, it should be protected from destructive activities, specifically tin mining. This study also suggests local government authorities to maintain the Sukal coastal waters as a center for cultivation.

Acknowledgements. The authors are grateful to the Center for Education Financial Services, Ministry of Education, Culture, Research and Technology, IPB University, and the University of Bangka Belitung. The authors are also thankful to the head of the Sukal fishing group, West Bangka Regency, Bangka Belitung Province for helping to connect with blood cockles cultivators.

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

References

Arapov J., Ezgeta-Balic D., Peharda M., Gladan Z. N., 2010 Bivalve feeding - how and what they eat? Ribarstvo 68(3):105-116.

Boyd C. E., Tucker C. S., 1998 Pond aquaculture water quality management. Kluwer Academic, Boston, USA, 700 pp.

Boyd C. E., Green B. W., 2002 Coastal water quality monitoring in shrimp farming areas: an example from Honduras. Department of Fisheries and Allied Aquacultures Auburn University, Alabama, 29 pp.

BPS, 2022 Institution of statistical center, Bangka Belitung Province 2022. Bangka Belitung Province in numbers. Bangka Belitung.

Chandra G., Sharma A. P., Sahu S. K., 2013 Impact of pen-culture technology on fish productivity of floodplain wetlands in Asom. Indian Journal of Animal Sciences 83(2):209-215.

Dalmiyatun T., Eddy B. T., Sumekar W., Mardiningsih D., 2018 Motivation of farmers to cultivate organic rice in Central Java. IOP Conference Series: Earth and Environmental Science 102:012043.

Diatin I., Effendi I., Taufik M. V., 2020 The production function and profitability analysis of *Gracilaria sp*. seaweed polyculture with milkfish (*Chanos chanos*) and black tiger shrimp (*Penaeus monodon*). Biodiversitas 21(10):4747-4754.

Diatin I., Shafruddin D., Hude N., Sholihah M., Mutsmir I., 2021 Production performance and financial feasibility analysis of farming catfish (*Clarias gariepinus*) utilizing water exchange system, aquaponic, and biofloc technology. Journal of the Saudi Society of Agricultural Sciences 20(5):344-351.

Dunham A., Marshall R. D., 2012 Using stocking density modifications and novel growth medium to control shell deformities and biofouling in suspended culture of bivalves. Aquaculture 324-325:234-241.

Epelbaum A., Pearce C. M., Yuan S., Plamondon N., Smith H. G., 2011 Effects of stocking density and substratum on the survival, growth, burrowing behaviour and shell morphology of juvenile basket cockle, *Clinocardium nuttallii*: implications for nursery seed production and field outplanting. Aquaculture Research 42(7):975-986.

Ferreira J. G., Falconer L., Kittiwanich J., Ross L., Saurel C., Wellman K., Zhu C. B., Suvanachai P., 2015 Analysis of production and environmental effects of Nile tilapia and white shrimp culture in Thailand. Aquculture 447:23-36.
Hernandez-Llamas A., Zarain-Herzberg M., 2011 Bioeconomic modeling and risk analysis of raising shrimp *Litopenaeus vannamei* in floating cages in northwestern Mexico: assessment of hurricane hazard, stochastic variability of shrimp and feed prices, and zootechnical parameters. Aquaculture 314(1-4):261-268.
Ibrahim, Haryadi D., Wahyudin N., 2018 From charm to sorrow: the dark portrait of tin mining in Bangka Belitung, Indonesia. People: International Journal of Social Sciences 4(1):360-382.
Ibrahim, Sulista, Pratama S., 2022 Struggling for power over the Bangka coast: tin amongst the vortex of companies, the state, and residents. The Extractive Industries and Society 10:101055.
Khade S. N., Mane U. H., 2012 Diversity of Bivalve and Gastropod, Molluscs of some localities from Raigad district, Maharashtra, west coast of India. Recent Research in Science and Technology 4(10):43-48.
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.
KKP, 2020 Statistics of Aquaculture Production in West Bangka Regency. Indonesia.
Kumar G., Engle C., Hanson T. R., Tucker C. S., Brown T. W., Bott L. B., Roy L. A., Boyd C. E., Recsetar M. S., Park J., Torrans E. L., 2018 Economics of alternative catfish production technologies. Journal of the World Aquaculture Society 49(6):1039-1057.
Kumar G., Engle C., Hegde S., van Senten J., 2020 Economics of US catfish farming practices: profitability, economies of size, and liquidity. Journal of the World Aquaculture Society 51(4):829-846.
Lee J. M., Chen S. H., Lee Y. C., Huang J. F., Schafferer C., Yeh C. Y., Kung T. W., 2022 Optimizing hard clam production in Taiwan by accounting for nonlinear effects of stocking density and feed costs on farm output of clams. Fishes 7:160.
Mugwanya M., Dawood M. A. O., Kimera F., Sewilam H., 2022 Anthropogenic temperature fluctuations and their effect on aquaculture: a comprehensive review. Aquaculture and Fisheries 7(3):223-243.
Mutea F. G., Nelson H. K., Au H. V., Huynh T. G., Vu U. N., 2021 Assessment of water quality for aquaculture in Hau River, Mekong Delta, Vietnam using multivariate statistical analysis. Water 13:3307.
Nicholaus R., Lukwambe B., Zhao L., Yang W., Zhu J., Zheng Z., 2019 Bioturbation of blood clam *Tegillarca granosa* on benthic nutrient fluxes and microbial community in an aquaculture wastewater treatment system. International Biodeterioration and Biodegradation 142:73-82.
Ondhoro C. C., Owoyesigire B., Gidoi R., Kubiriza G. K., Atukunda G., Turyashemererwa M., Naluwairo J., Magezi G., Owere L., 2021 Productivity and profitability of aquaculture enterprises in Uganda’s South Eastern Agro-Ecological Zone (U’SEAEZ). International Journal of Agricultural Policy and Research 9(4):98-110.
Pahri S. D. R., Mohamed A. F., Samat A., 2016 Preliminary water quality study in cockle farming area in Malaysia: a case study in Jeram, Selangor. AACL Bioflux 9(2):316-325.
Palupi M., Fitriadi R., Dadiono M. S., Kusuma R. O., Yonarta D., 2021 Profitability analysis of tiger grouper hatchery (*Epinephelus fuscoguttatus*) household scale in Kelatakan Village, Situbondo, East Java. Journal of Aquaculture and Fish Health 10(2):192-198.
Ponto J., 2015 Understanding and evaluating survey research. Journal of the Advanced Practitioner in Oncology 6(2):168-171.
Rifardi, 2008 [Sediment texture: sampling and analysis]. Unri Press, Pekanbaru, 101 pp. [in Indonesian]
Riniatsih I., Wibowo E., 2010 Substrat dasar dan parameter oseanografi sebagai penentu keberadaan gastropoda dan bivalvia di pantai Sluke kabupaten Rembang. Jurnal Ilmu Kelautan 14(1):50-59.

Riza S., Gevisioner, 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.
Salaenoi J., Sukudom C., Wongsin T., Sirisuay S., 2015 Sediment quality in cockle culture and non-cultured area at Bandon bay, Thailand. Proceeding of International Conference on Plant, Marine and Environmental Sciences, Kualalumpur 1:110-114.
Santoso P., Marsoedi, Maftuch, Susilo E., 2015 Strategy 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(6):1-9.
Sevilla C. G., Ochave J. A., Punsalan T. G., Regala B. P., Uriarte G. G., 2007 Research methods. Rex Printing Company, Quezon City, 246 pp.
Srisunont C., Nobpakhun Y., Yamalee C., Srisunont T., 2020 Influence of seasonal variation and anthropogenic stress on blood cockles (*Tegillarca granosa*) production potential. Journal of Fisheries and Environment 44(2):62-82.
Sulistiyaningsih E., Arbi U. Y., 2020 [Bio-ecological aspects and utilization of the *Anadara* (Mollusca: Bivalvia: Arcidae)]. Oseana 45(2):69-85. [in Indonesian]
Suryana A. A. H., Amalia D. H., 2021 Analysis of competitiveness fisheries processing industry in Indonesia. Asian Journal of Fisheries and Aquatic Research 15(5):30-42.
Syahira S. N., Nithiyaa N., Nooraini I., Tan S. H. A., 2021 Preliminary study on the growth development of blood cockle (*Tegillarca granosa*) by using different substrates in the hatchery system. Journal of Survey in Fisheries Sciences 7(2):71-78.
Tumwesigye Z., Tumwesigye W., Opio F., Kemigabo C., Mujuni B., 2022 The effect of water quality on aquaculture productivity in Ibanda District, Uganda. Aquaculture Journal 2(1):23-36.
Ukav I., 2019 Application of break even point analysis on some agricultural products. The case of Kahta (Adiyaman) District. Journal of Economics and Sustainable Development 10(16):84-89.
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.
Yurimoto T., Kassim F. M., Man A., 2014 Digestive tube contents of blood cockle (*Anadara granosa*) in a tropical mangrove estuary in Malaysia. International Journal of Aquatic Biology 2(4):180-183.

Received: 21 October 2022. Accepted: 02 November 2022. Published online: 11 November 2022.
Authors:
Eva Prasetiyono, Department of Aquaculture, Faculty of Fisheries and Marine Science, Bogor Agricultural University, Bogor-West Java, 16680, Indonesia, e-mail: evaintegral@gmail.com
Kukuh Nirmala, Department of Aquaculture, Faculty of Fisheries and Marine Science, Bogor Agricultural University, Bogor-West Java, 16680, Indonesia, e-mail: kukuhni@apps.ipb.ac.id
Eddy Supriyono, Department of Aquaculture, Faculty of Fisheries and Marine Science, Bogor Agricultural University, Bogor-West Java, 16680, Indonesia, e-mail: eddysupriyonoipb@gmail.com
Sukenda, Department of Aquaculture, Faculty of Fisheries and Marine Science, Bogor Agricultural University, Bogor-West Java, 16680, Indonesia, e-mail: sukenda67@gmail.com
Yuni Puji Hastuti, Department of Aquaculture, Faculty of Fisheries and Marine Science, Bogor Agricultural University, Bogor-West Java, 16680, Indonesia, e-mail: yunipujihastuti2014@gmail.com

How to cite this article:
Prasetiyono E., Nirmala K., Supriyono E., Sukenda, Hastuti Y. P., 2022 Analysis of environmental quality, production performance and economic feasibility of *Anadara granosa* cultivation in Sukal, Bangka Belitung Province. AACL Bioflux 15(6):2881-2891.