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A CONCEPT OF OPEN-CLOSED SEASON APPROACH FOR INDONESIAN BLUE SWIMMING CRAB (*PORTUNUS PELAGICUS*) MANAGEMENT ON THE NORTH COAST OF JAVA

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Abstract

The open-closed season approach has not been widely used in fisheries management in Indonesia, including blue swimming crab (BSC) fisheries that created ecological and economic balance. This research aims to illustrate the characteristics of BSC fishers, examine the application of the concept of the open-closed season in blue swimming crab fisheries, and predict the sustainability of fishermen's livelihoods. Data collection was conducted in 2020 and 2022 in four regencies: Rembang, Demak, Cirebon, and Lampung. However, Lampung is excluded in 2022. The primary data were obtained from structured questionnaires sent to 520 fishermen and 63 mini plants and collectors, then analysed by descriptive analysis, Likert scale, and business sustainability index. The findings showed that blue swimming crab fishing characteristics at four research sites showed different conditions. Working as fishermen cannot contribute sufficiently to improving the household economy. The factor influencing the blue swimming crab fishing business is the size of the fishing boats. The open-closed season (OCS) policy is worthy of short-term goals consisting of fishermen's welfare and business justice in business actors and long-term goals, namely the sustainability of blue swimming crabs. Institutional schemes are proposed for the OCS model to maintain the sustainability of resources and businesses.

Keywords*: Open-closed season; Livelihood sustainability; Blue swimming crab; Fishery management*

Introduction

The blue swimming crab fishery became a source of income that immensely helped the economic growth of coastal communities in the 1990s. However, the human population change also affects the provision of livelihood resources as income for coastal communities [1]. In Indonesia, livelihood development strategies have been carried out in various ways by governments, NGOs, and international institutions to increase and diversify the income sources of coastal communities [2]. The most significant contribution is in the waters of the Java Sea.

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During 2012-2017, the production volume and value of blue swimming crabs and crab exports in Indonesia averaged growth. Production volume increased by 0.88, while production value increased by 6.15.

The sustainability of blue swimming crab capture efforts positively correlates with the growth of blue swimming crab processors or mini-plans in blue swimming crab-producing centres, including fisheries management areas (WPP) 712, 713, 711, and 571. According to *E.S. Wiyono and Ihsan* [3], the blue swimming crab catch in Indonesia is short, starting in May-June as the peak season, but they use the same fishing gear throughout the year. The common problem is that small-scale fisheries such as blue swimming crabs can create livelihoods worldwide but are usually weak in surveillance and control [4]. The Indonesian Blue Swimming Crabs (BSC) Management Association (APRI) states that BSC fisheries involve nearly 90,000 fishers and 185,000 blue swimming crab strippers. That's an increase of almost 11% since 2011.

The supply chain of blue swimming crabs is mainly labor-intensive,, especially in capture and processing efforts. Therefore, high-value fisheries that usually enter export supply chains negatively impact lower-value species commonly sold to local markets [5]. In Indonesia, the pattern of blue swimming crabs' production flow starts with fishers selling them to collecting traders, then being processed by the mini plant in collaboration with managing merchants. A mini plant guarantees fishermen's blue swimming crabs' marketing aspect, mainly produced to meet export needs. According to *A. Malak-Rawlikowska et al.* [6], a short supply chain will benefit producers and result in high purchase prices from an economic point of view.

Efforts to use blue crab resources in Indonesia have been regulated by approaching the number and size of fishing gear (input control) and the number and size of catches (output control). The input control approach practiced in Europe has a significant role, but this approach is not suitable for using the quota approach in the Atlantic [7]. However, according to Wang et al. [8], the hybrid input-output control process method is helpful for a more comprehensive and sectoral approach to policy to assess the costs and benefits of resource taxation. However, production and size have declined over the past ten years. Therefore, they can indicate disrupted ecological conditions that could impact the economy. For example, some Indonesian Water Management Areas (WPP) 711 and 717 have been overexploited. In addition, the rapid growth of mini-plants has led to increased fishing, which tends to get out of control. Therefore, settlement arrangements include alternative restrictions on arrest quotas, the number of ships, the number and type of fishing gear, the arrest area, and the arrest season. However, increasingly uncertain conditions in small-scale blue swimming crab capture efforts because of changes in ecological conditions, as outlined above, will increasingly affect the sustainability of fishermen's livelihoods. Therefore, predicting the sustainability of efforts to capture blue swimming crabs is very important because it impacts the livelihoods of coastal communities. Specifically, this research aims to: i) describe the characteristics of small-scale blue swimming crab fishers in the northern coastal region of Java; ii) review the concept of the open-closed season on blue swimming crab fisheries in Indonesia; and iii) analyse the sustainability of the livelihoods of small-scale blue swimming crab fishers.

Experimental part

Materials

Characteristics of crabs: they live in estuarial areas and migrate to waters that have a higher salinity. Small crabs live in shallow areas, are ready to enter the mating period, and migrate to coastal areas. Since the 1990s, crabs have become an essential source of income for coastal communities. Crab fishing in Indonesia is distributed in fisheries management areas 712, 713, 711, and 571. The most significant contribution is in the waters of the Java Sea. Figure 1 describes the research locations in Central Java Province and Lampung Province. Both areas are

located in National Fisheries Management Area 712 and become the production centre or fishing area for blue swimming crabs.

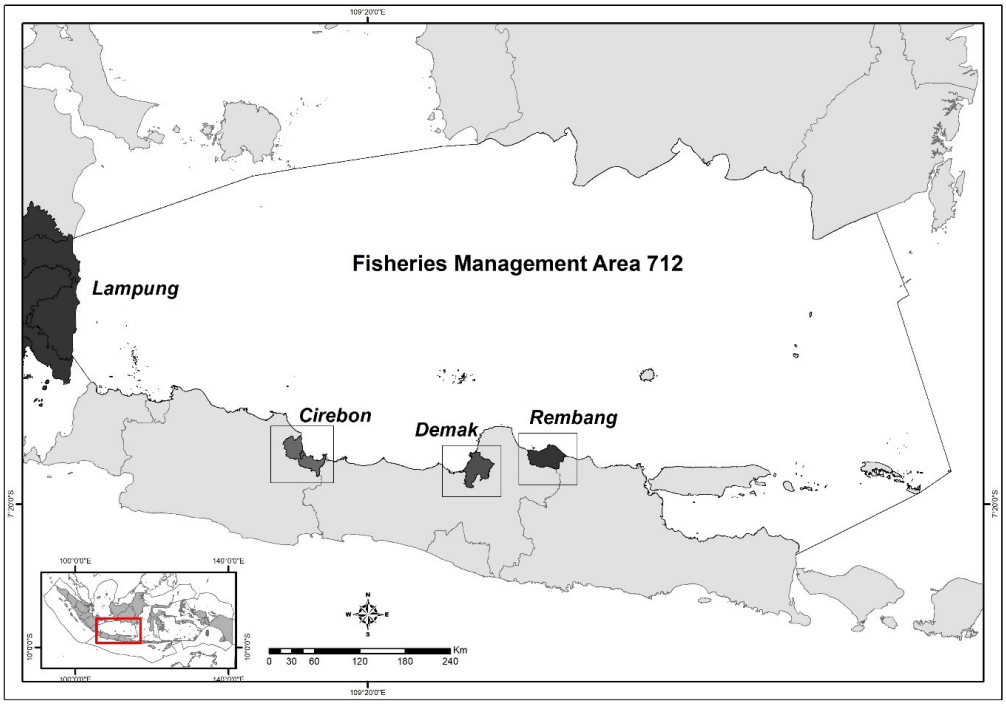

Fig. 1. Research Area

The data were based on primary data obtained from fishermen, blue swimming crab processors, and other stakeholders. Primary data collection during the COVID-19 pandemic has two stages and methods. First, the data is collected by an enumerator using a structured questionnaire. In addition, a coaching questionnaire was conducted on the enumerators before collecting data from the respondents. Second, in-depth interviews with blue swimming crab fishers and related stakeholders such as community leaders, collectors and traders of blue swimming crabs, and other stakeholders related to the research theme The respondents were 520 fishermen and 63 collectors and processors, collected using structured questionnaires.

Methods

The data collected is analysed using mixed methods: quantitative and qualitative descriptive, perception analysis with the Likert scale, and fishermen's household sustainability index.

Descriptive Analysis

The descriptive qualitative analysis aims to describe and summarise various conditions and situations or phenomena of social reality in society and seeks to bring that reality to the surface as a characteristic, character, nature, or picture of a particular condition, situation, or phenomenon. The analysis of descriptive diagrams is also used to describe the crab's fishery governance model with an open-closed-season approach.

Perception Analysis

Internal and external factors influence fishermen's perceptions. Internal factors are the values within each individual that dictate the things they accept. External factors are values from each self that can influence perceptions, e.g., objects and situations. This perception can affect fishermen's decisions on blue swimming crab fishing activities. Fishermen's perception is measured using the Likert scale. The Likert scale is a standard method for data collection in

quantitative research or mixed methods [9]. The respondent determines their level of approval of a statement by selecting one of the available options. This perception answer can use the Likert scale on five scales [10]. This study has a strongly disagree, disagree, agree, agree, strongly agree. The researcher will calculate the lowest and highest ranges. The perception analysis was used to analyse the alternative actions for core and supporting policies in the open-closed season approach.

Index of Household Economics Sustainability (iKERT)

The Marine and Fisheries Household Economic Sustainability Index, or *iKERT,* is a model formulated to calculate the economic sustainability index of marine and fishery households with a *sustainable livelihood* approach based on five main capitals: natural, human, financial, physical, and social. The *iKERT* is developed based on a "*sustainable livelihood"* approach based on five principal capitals, namely: natural capital *(IXA_i),* human capital *(IXO_i),* financial capital *(IXU_i),* physical capital ($IXFI_i$), and social capital *($IXSO_i$).* This analysis measures the livelihood sustainability of crab fishermen when the open-closed-season approach is implemented to govern crab fisheries.

Results and discussion

The results and discussion are divided into three parts. *They first explained* the characteristics of small-scale crab fishermen on the northern coast of Java. *Second*, explaining the open-closed season approach, especially related to existing issues and new concepts in crab fisheries management, *Third*, describing the sustainability of the household economy in the context of an open-closed season approach.

The Characteristics of Small-Scale Blue Swimming Crab Fishers

The characteristics of crab fishermen and crab collectors are based on interviews using structured questionnaires with respondents at the research site. The variables analysed included age, level of education, number of family members, income, expenses, and investments.

In general, the fishing activity of crab fishermen in the four research sites is mainly 30–50 years old. This age range is ideal, considering that working as a fisherman requires a lot of physical activity compared to working on the land. The research location with the most significant percentage of age ranges over 50 years is Cirebon Regency, with a percentage value of 39%. Meanwhile, the most important category value for respondents under 30 is the Lampung location. Generally, they only finished elementary school compared to junior high, high school, and college. The respondent population with the most considerable level of primary school education was fishermen in Cirebon (97%), followed by fishermen in Demak Regency (76%), Rembang Regency (71%), and Lampung (64%). Most fishermen have experienced crab fishing activity between 10 and 20 years and 20 and 30 years, which means that they have had qualified experience in blue swimming crab fishing.

According to their level of education, crab fishermen have poor education levels. They are only completed in elementary school rather than junior high and senior high school as well as college. This condition makes them more vulnerable to the dynamics of socioeconomic change [11]. According to *S. Siregar et al.* [12], the awareness of the fishing community about their children's education was low, and it was due to the fact that the parents education was also poor and a lack of understanding of the importance of formal education for children. The low level of education among fishing communities is a common phenomenon in the fishing communities of Indonesia. The causes are many, but some of them, as mentioned by *S. Siregar et al.* [12], are that (i) there is a pragmatic perception from parents in coastal areas that education or schools do not provide income, (ii) high education levels may not guarantee being able to get a better job, and (iii) there is a short-term orientation from fishing communities that tend to a consumptive lifestyle rather than a long-term orientation. In addition, the availability of educational infrastructure is relatively lower in coastal areas compared to urban areas.

Furthermore, figure 2 explains the length of work experience offered by the first-time respondents who worked as fishermen in the age range of 15–30 years old. On the other hand, the experience of mini plant/crab processor respondents mostly ranges from 10 to 20 years, except crab fishermen in Lampung have less experience, less than ten years. Meanwhile, 7-8% of crab processors in Rembang Regency and Cirebon Regency have vast business experience spanning more than 30 years. The longer respondents' experience, the more technical information and knowledge will improve their business.

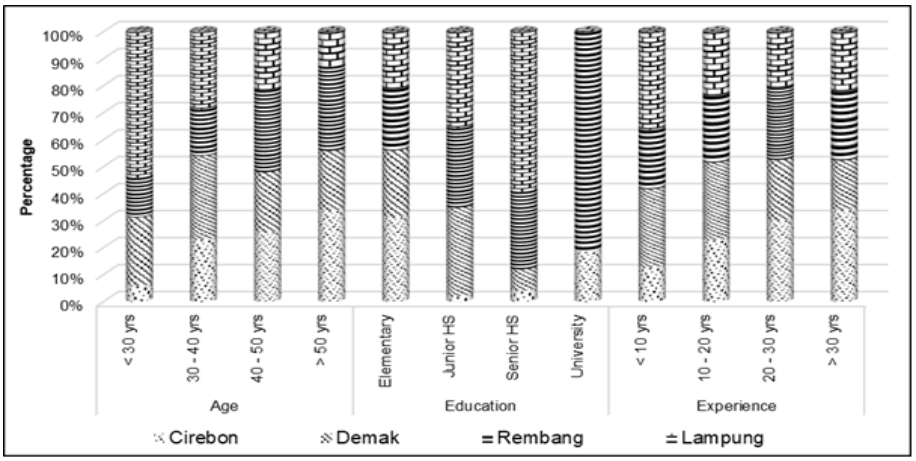

Fig. 2. Characteristics of Age, Level of Education, and Work Experiences

Figure 3 explains that the average income of fishermen's respondents ranges from Rp. 2–4 million per month, judging from the primary income. This condition shows that employment activities such as fishing are relatively unable to contribute enough to the improvement of the household economy. Therefore, these values can generally only be used for household consumption purposes. About 27 and 20% of fishers in Lampung and Cirebon earn more than 8 million per month. The production and price of blue swimming crabs influenced the respondent's opinions. Recently, the survey found that the price of blue swimming crabs ranges between IDR20,000 and IDR40,000 per kilogram. In crab processing, the primary income received by crab peeler respondents was dominated by high revenue (>Rp 8 million) for the Lampung (76%) and Cirebon (69%) locations. Respondents in Demak received a primary income of Rp 6–8 million, and Rembang amounted to Rp 4-6 million. The high income from crab processing shows that this activity improves the household economy, especially crab peeling. This business impacts the absorption of labour for the surrounding environment, especially homemakers who work peeling and boiling crabs. The high and low income depend on the production of crabs and the price of crabs.

In Demak Regency, most respondents have invested in blue swimming crab fishing activities worth about IDR 20–40 million. In contrast, the fishers in Lampung have a minor investment in the same action (less than 20 million rupiahs). The size of the fishing boat is the most dominant factor influencing the investment. The larger fishing boat will need financial investment. Blue-swimming crab fishermen in Demak Regency are relatively less able to allocate their income to make new business investments than in other locations. However, blue-swimming crab fishermen in Lampung are more interested in reinvesting in fishing activity within a year in standard time. The investment in crab processing and trading businesses varies for the four research sites. The dominance of investment is directly proportional to the scale of industrial enterprises (micro, small, and medium scale). An enormous investment value (IDR 5-7 million) is owned by respondents in Lampung Regency, with a medium business scale. While

the respondent in Rembang and Demak has an investment of only < IDR1 million. The low investment value was due to the respondent's business being classified as micro-scale by doing business in front of his house (peeling and boiling) without helpful labour and simple equipment. The size of the investment value of the crab processing business is greatly influenced by many factors, including transportation equipment, freezers, and production space.

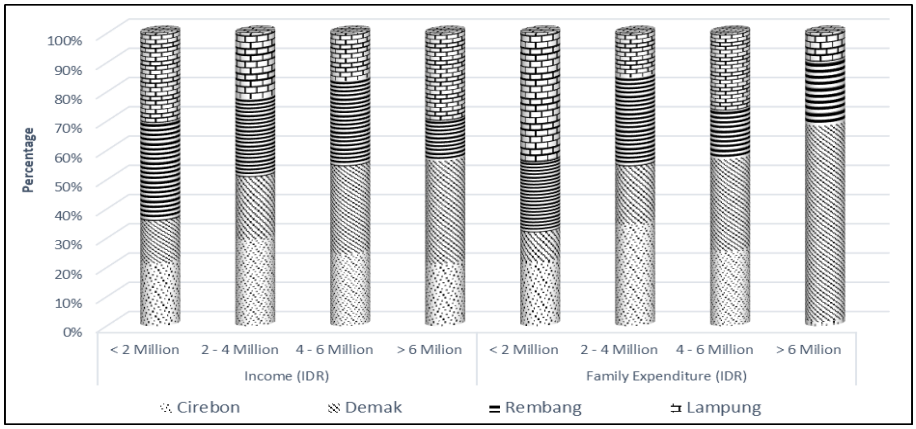

Fig. 3. Income and Expenditure of Blue Swimming Crab Fishermen

Most crab fishermen have expenses ranging from IDR 2 to IDR 4 million per month. The number of family members, the price of necessities, and the high or low cost of family health and education influence fishermen's expenses. The conditions in Lampung are different, and crab fishermen can meet their household needs because their income is more prominent than their expenses (less than 2 million). Fishermen find it difficult to save their money because they think that their income will be spent on today's expenses, and then they will get money again tomorrow from the crab fishing activity. This fishermen's understanding needs to be educated so that fishermen do not borrow money from a moneylender or informal bank when they need urgent cash or for school, health, or fishing needs. Related to crab processing, most of the respondents' expenses in Lampung amounted to less than IDR 2 million per month (56%). The small value in expenditures is because the price of necessities is relatively low compared to Java, such as in Rembang, Demak, and Cirebon Regencies, where the total household expenditure amounts are IDR2-4 million per month (34-55%).

Low levels of education can be an obstacle to the implementation of programmes to improve fishermen's welfare through technology transfer. Fishermen who have children can be employed to help their parents catch crabs. In Indonesia, this is very common for the children of fishermen involved in all fisheries activities [2]. It is evident that education is an essential aspect of human capital variables in building governance models; it can have a positive as well as a negative impact [13]. They have an income higher than the regional minimum wage. A regional minimum wage is a unit of value agreed upon by the local government regarding what value a company or workplace must meet for its workers to live a decent life. The average crab fisherman at the four research sites has one work activity. This condition is very positive for households, considering that the price of blue swimming crabs is good enough. Although it occasionally fluctuates, in general, the cost of crab commodities, including mud crabs, is relatively stable [1]. However, BSC fishermen will be vulnerable when they still depend on a single income. As *M. Ali and A. Zamroni* [14] mentioned, fishermen cannot estimate how much catch is obtained from daily fishing—working as a fisherman is generally more time-allocated than on the mainland. In the case of crab fishermen who have used crab bottom gillnets (called

kejer), they can do another work activity outside of fishing due to the time allocation being longer than catching crabs using a mini trawl and dredged net.

Figure 4 describes that the age variables have no relationship with the primary income, total income, or household expenses. Older fishermen do not necessarily earn more income compared to younger fishermen. However, *Q. Chen et al.* [11] argued that the age of fishermen could affect their adaptation difficulties to new jobs as a source of livelihood. In the case of small-scale crab fishermen, all age levels have the same opportunity to obtain household income and expenditure. However, young fishermen may have more extraordinary expenses due to their hedonistic lifestyle than older fishermen. Those conditions may require a change in fishermen's mindsets to improve their financial management patterns. According to *M. Ali and A. Zamroni* [14], improvements in fishermen's incomes and livelihoods will affect their role in protecting the coastal environment and the resilience of their communities. In the investment variable, operational costs and maintenance costs have a low correlation. The BSC fishing business causes this condition in small-scale crab fishermen, so the cost factor is considered to have a relatively small influence. However, *S. Lawless et al.* [15] suggest that investment development can be carried out by improving and creating livelihood opportunities. However, based on the relationship between age, education, and work experience, it can be seen that older crab fisherman tend to have low education, but they have more experience (Fig. 5). Therefore, education can negatively affect livelihood sustainability [16].

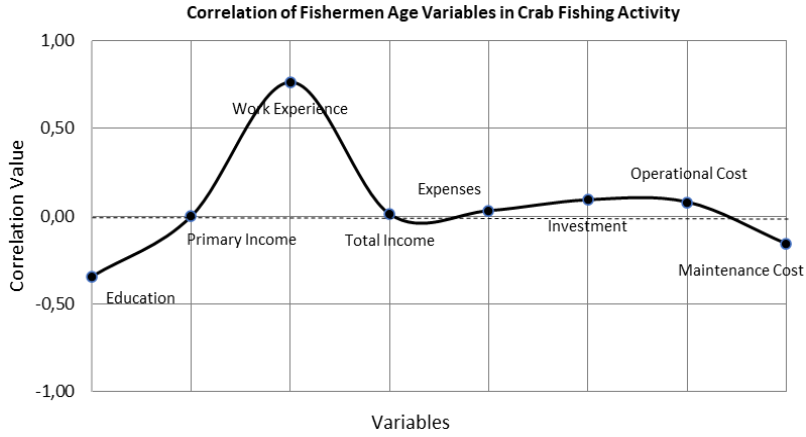

Fig. 4. Correlation of Fishermen's Age Variable with Other Variables in Crab Fishing Activity

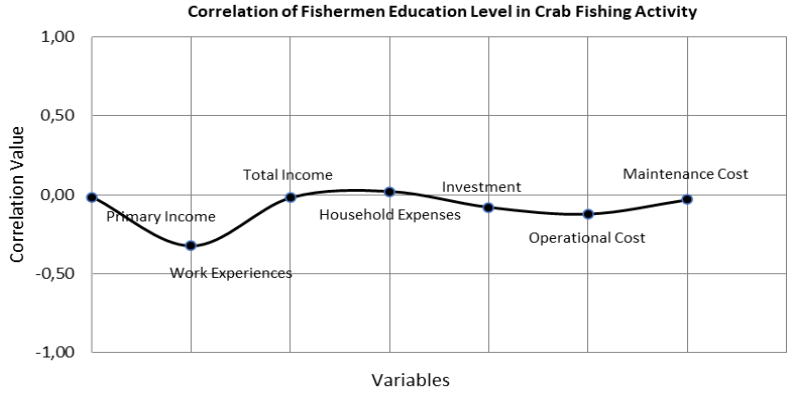

Fig. 5. Correlation of Fishermen's Educational Variable with Other Variables in Crab Fishing Activity

Figure 5 explains the relationship between crab fishermen's education variable and shows no real correlation with the primary income, total income, household expenses, investment, and maintenance costs. On the other hand, educational variables with work experience have a negative correlation value. Therefore, the higher education of fishermen means they have less work experience as fishermen.

Open-closed season (OCS) approach: Issues and concept possibility

The issues in crab fisheries are generally divided into three categories: i) natural resource utilisation; ii) socioeconomic; and iii) governance. Issues related to the utilisation of crab resources include: i) degradation of the stock of blue swimming crab resources; ii) the capture of egg-laying crabs and the minimum size of crabs that can be caught; iii) degradation of crab habitats; and iv) unreported or unrecorded crab catches. Socioeconomic issues are related to: i) increasing market demands for products that require a minimum size that can be caught and prohibitions on the capture of egg-laying crabs; ii) fishermen's access to financial institutions; and iii) public awareness of the use of environmentally friendly crab fishing gear. Meanwhile, the issues of governance cover: i) knowledge and awareness of fishermen, collectors, mini-plans, and other stakeholders about the importance of crab sustainability; ii) implementation of law enforcement is not optimal yet, particularly for harvest control; and iii) partial participation of crab fishermen in the decision-making process.

Most respondents prefer to limit the BSC size rather than manage the number of fishing gear and arrangements through the prohibition of the open-closed approach. *D.B. Nrunnell et al.* [17] explained that the implementation of the maximum size approach could be used as a warning of the biological conditions of the water or species. However, these opinions must be further examined, especially for the catch's environmental aspects, volume, and quality. Control of the demand side or export market on the quality and size of crabs will influence fishing gear utilisation policies, fishing grounds, and production volumes. In addition, the choice or strategy of multiple fishing gear utilisation is focused on sustainable solutions for fishermen's livelihoods, especially when off-fishing the crab fishery. The ban on non-environmentally friendly fishing gear must be strictly implemented, even though the fishing gear is still on a small scale. It was driven by the social benefits received by fishermen, processors, and middlemen [18]. Law enforcement from *PermenKP* 12/2020 concerning fishing grounds, which regulates types of fishing gear, needs to be improved, especially in supervision and education of the community. *V. Owusu and E. Andriesse* [19] reinforce that the closed season must be accompanied by law enforcement and consider the community's welfare.

Open-closed fishing areas and seasons are a part of the fisheries resource management approach that is conceptually simple and easy to explain to various stakeholders regarding the reasons for the determination and the mechanism of its approach. The approach of enforcing closed areas and closed fishing seasons will make it easy in several ways: i) stock protection in complex fisheries or poor data conditions; ii) to protect by-catch species that cannot be protected in any other way; and iii) to protect sensitive benthic habitats [20]. The open-closed season approach has been widely used as a fisheries management tool, and its benefits have been commonly exercised in fisheries resource management. In the case of Lampung, spatial and temporal-based crab management is necessary as a reference for limiting crab fishing efforts [21]. A closed season in the fishery is an effective management measure to protect critical reproductive activities. The closed season during the period of peak spawning activity is effective in protecting resources. Likewise, crab commodities also have a high value as export commodities. The high value of crab benefits leads to many crab fishing attempts. A management strategy that pays attention to the carrying capacity of crabs must be a reference so that the utilisation of crab resources can be carried out sustainably.

The open-closed-season approach has been applied in several countries, showing different results. Restrictions on fishing gear, combined with the closed season of open water on the South Coast of England, have increased its abundance and benthic fauna biomass [22]. Most

closed fishing seasons are based on in-depth knowledge of fish behaviour and life cycles [23–25]. The closed fishing season in the spawning period is more widely applied to better catching conditions to preserve sufficient spawning potential for reproduction. The closed fishing season designed to protect spawning aggregations in the northeastern United States has a minimal effect due to the rate of effort outside of enclosed areas and increased aggregation efforts after the closure ends. This research describes the socioeconomic model through several indicators, *output* expectations, functions, and outcomes at each stage. Indicators consist of social, economic, and ecological indicators.

The role of this model concept is to look for the basic model of blue swimming crab capture management. This model's scope has not yet been approved for all specific locations. However, this research expects an initial model to develop into a new approach to the governance of blue swimming crabs. The prototype of the open-closed season socioeconomic model in blue swimming crabs' management considers five main capitals, namely physical, human, financial, natural, and social. The five main capitals have different variables. The physical aspect defines several variables: production inputs, public transportation, and essential services. The human capital variable consists of age, education level, number of family members, work experience, and type of work. Besides, the financial capital covers the economic or financial institution, income trend, fishing efforts, and trend prices. Natural capital consists of governance institutions, production trends, fishing activity and gear, fishing grounds, and fishing seasons. Finally, social capital consists of fishermen's perceptions, social institutions, community organisations, and business groups. These variables are also available for measuring household businesses' sustainability based on blue swimming crabs' capture. The above five capitals will also determine the closed area and closed season, as well as the recommended fishing gear for capturing blue swimming crabs as the central policy of this open-closed season approach. The point is to look for the formula and the scope of open-closed management.

Two variables in the question related to existing rules, namely: i) the size limitation of crabs caught and ii) the effectiveness of the size limitation rules. Based on the perception analysis from four research sites, fishermen agreed with the size limitation of crab fishing (Cirebon (79%), Rembang (66%), Lampung (66%), and Demak (39%). However, the effectiveness of those rules' implementation is still relatively low. The respondent stated that the execution had not been effectively implemented in the field. The results of observations show that BSC fishermen have not yet obeyed the fishing policy of Ministerial Regulation of Marine and Fisheries No. 12 (PERMEN-KP) 2020 concerning the management of lobsters (*Panulirus spp.*), crabs (*Scylla spp.*), and crabs (*Portunus spp.*) in the Territory of the Republic of Indonesia. Furthermore, the width of the carapace of crabs caught by fishermen is still a lot, at under ten centimetres or under sixty grammes per head, and many crabs lay eggs. The fishermen's reason is that the crab is dead if it is already caught, and it is impossible to release it into the sea again.

Figure 6 describes the implications of the open-closed season model for crab fisheries management, which can be seen in changes in the number of crab stocks, changes in the amount of production, and changes in income from crab fishery business actors using a dynamic system. Unfortunately, as a public policy, closed seasons, in some cases, do not appear to be ineffectively utilised to manage resources because fishermen do not comply [26] and have a negative opinion from the public [19]. Furthermore, they mention four consequences of the open-closed season that need to be anticipated: limited access to coastal waters, declining financial capital, declining fish trade, and reduced opportunity for small-scale fisheries. The fish growth model uses a logistics growth model, and the production/fishing model uses the Cobb-Douglas model. In this study, it was distinguished between small crab stocks and large crab stocks by knowing the maturity rate of crabs. Simulations are carried out with a reduction in initial fishing efforts representing the open and closed fishing seasons.

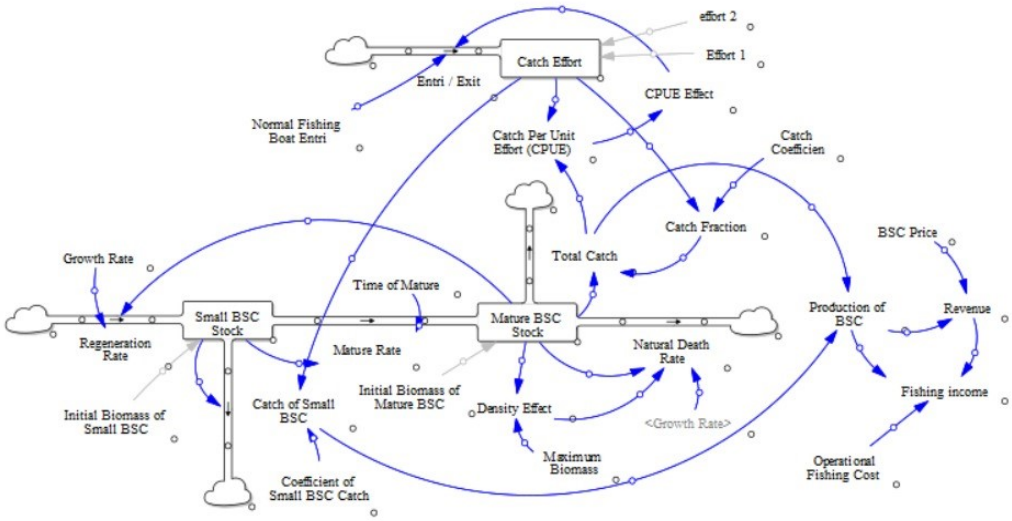

Fig. 6. Stok-flow Diagram of Blue Swimming Crabs Fishery in Open Closed Season (OCS) Perspective

The simulation results showed that the stock of small and large blue swimming crabs increased with a reduction in fishing efforts. Figure 7 shows that the condition of crab stocks continues to decline when there is no policy to reduce fishing activities. The policy of lowering fishing efforts by 10% has not been able to restore the condition of crab stocks, as can be seen from the dynamics of declining crab stocks.

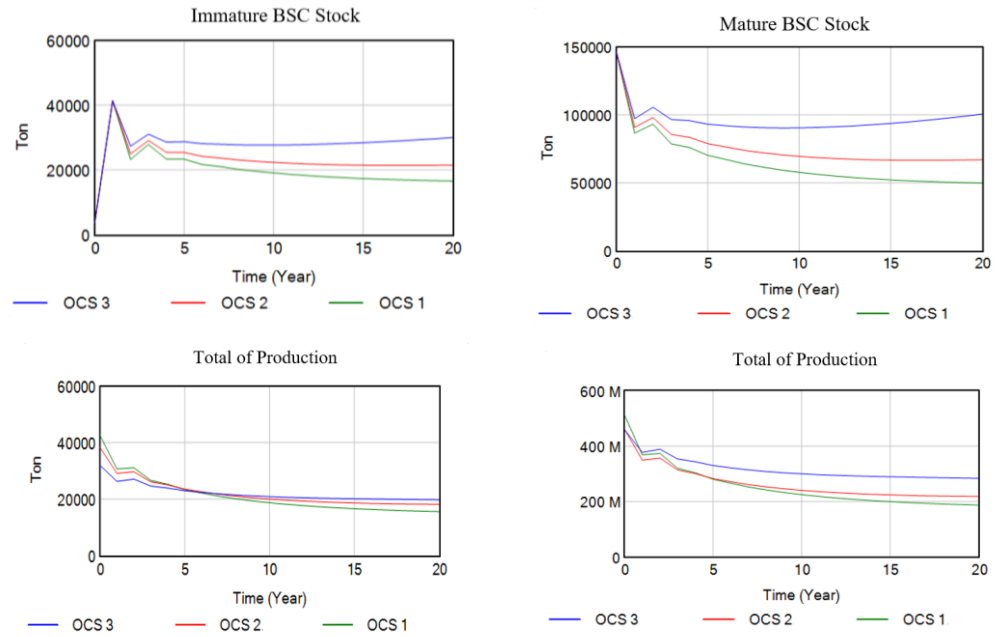

Fig. 7. The Simulation of Dynamic Scenarios for Blue Swimming Crab Management with an Open-Closed Season Approach

However, reducing fishing efforts by 25% can restore the shape of crab stocks in the long term. According to *T.H. Fauzi et al.* [27], massive blue swimming crab fishing for a long time will lead to growth overfishing, affecting temporary population loss and changes in the food chain. In the short term, the reduction in fishing efforts led to a decrease in blue swimming crab production, but it would increase output in the long term. The exploitation of blue swimming crabs in Indonesia is still in the range of 29–49% of the Maximum Sustainable Yield (MSY) and Maximum Economic Yield (MEY) on average [28]. The dynamics of changes in fishing income or income from crab fishing businesses show the same pattern as the dynamics of total production. Based on the law of supply and demand, when the amount of production decreases, the price of crabs will increase. The simulation assumed that when fishing efforts are reduced by 25%, the price of crabs increases by 10% from the base price. Thus, the reduction in fishing efforts also causes an increase in income from the business of blue swimming crab. Biologically, *A. Ben-hasan* [29] argues that alternative income sources can hinder the rate of biomass losses due to reducing fishing efforts. Otherwise, the opposite condition will occur. Then, fishermen can increase their efficiency when fishing rates are low [30].

The following simulation compares the conditions when fishing efforts were reduced over four years. The simulation results show that the closure of the fishing season for four years has caused an increase in the number of crab stocks but has not been able to restore their condition (Fig. 8). In the case of China, the closure period is predicted to drive a large wave of rapid fishing efforts to halt the benefits of rapid growth [31]. Therefore, to achieve the recovery of crab stocks, the arrangement of fishing efforts must be carried out for ten years. According to *P.G. Carvalho et al.* [32], short closing periods are suitable for large closing areas and well-managed fisheries. Meanwhile, long closure periods are ideal for narrower or smaller closure areas and overfishing.

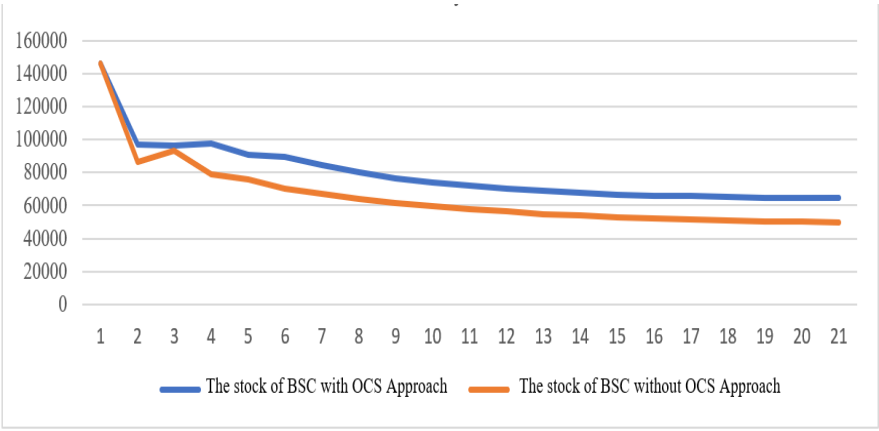

Fig. 8. The Condition of Mature Blue Swimming Crab Stock Without and With Closed Season for Fourth Years

Figure 9 explains that the primary policy for the open-closed season approach is defined as three factors that need to be regulated: the closed season period, the closed area for blue swimming crab fishing, and fishing gear. These three rules are explained in detail in the following description: This core policy needs additional supporting policies. The objective of establishing supporting procedures is to overcome the impact caused by the open-closed policy this season. Some supportive policy measures that can be an option are socialisation, facilitation, incentives, social safety nets, market management, surveillance, and law enforcement.

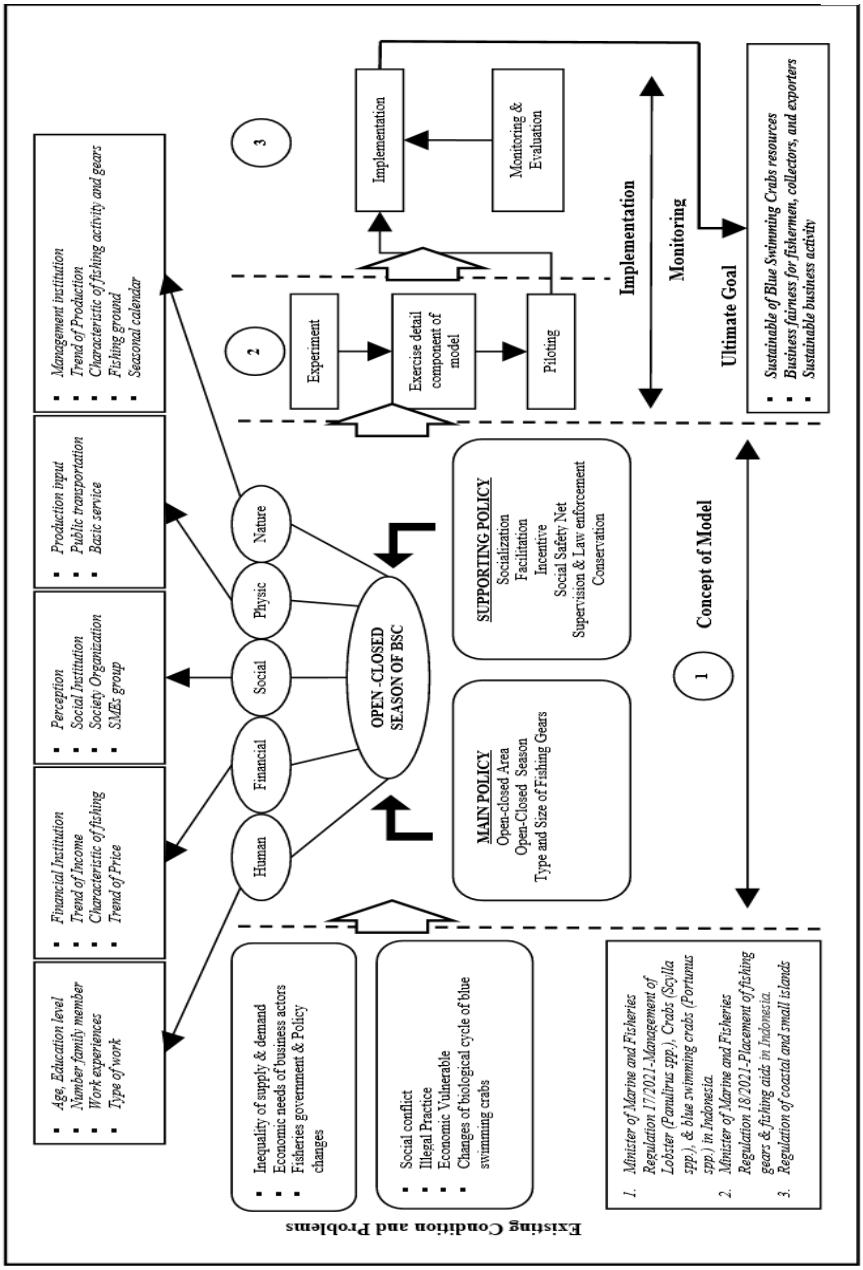

Fig. 9. The Concept Model of an Open-Closed Season for Governing Blue Swimming Crab Fisheries

The period of open-closed season period

The period of the open-closed season for managing blue swimming crabs is basically to limit the scope of this open-closed season. There are two primary considerations in determining the time of the fishing season in the temporary closure: i) the peak fishing season of blue swimming crabs, and ii) the spawning season of blue swimming crabs. A closed season can be applied in the spawning area when the peak season differs from the spawning period. However, the approach needs to be careful during the spawning and peak fishing seasons, especially multiplayer effects, because it would threaten the sustainability of the blue swimming crab's

resources, quality, and size. In this case, a fishing ground arrangement must accompany the closed season. The policy of closed seasons and fishing areas generally aims to increase fish catches, improve fishermen's income, and provide other benefits for coastal communities. In shrimp, sardine, lobster, and other commodities, the closing season approach has been implemented even in small-scale and large-scale fisheries businesses [19, 33, 34]. Some of these policies give positive results, but others have adverse effects because the goals are challenging to achieve and society is chaotic.

In the blue swimming crab's commodity, the open-closed season arrangements need to consider the spawning time of the item itself. Biology and ecology research results show that various spawning seasons follow location characteristics. There are two semesters for intersecting periods: a) January to June and b) September to December. A summary of information gathered from respondents describes that from January to June, the production volume of blue swimming crabs caught is enormous, but they are tiny in size; however, from April to June, the crab size goes to the juvenile phase. Most of the BSC caught are males. From July to September to November, there is a crab mating season, and finally, November to March is the time to lay eggs and spawn. Fishermen mention that the blue swimming crabs' peak season is from January to May. Then, June to December is an off-season period for fishermen. However, the possible time of the closed season is between August and September. The off-season is also related to wind conditions and the marine environment (called the west monsoon season); other information mentions that the west monsoon season on the northern coast of Java starts from November to January. During these months, fishermen get fewer blue swimming crabs than in other months due to being unable to catch the crabs or the absence of blue swimming crabs (Table 1).

Table 1. The characteristics of the life cycle of blue swimming crabs over a year

Criteria	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Des
1. Lay eggs, and the Spawning season	√	√	√								√	√
2. Juvenile crab season				√	√	√						
3. Male crab season							√	√	√			
4. Mating season									√	√	√	
5. High Crab Production	√	√	√	√	√	√	√					
6. Low Crab Production								√	√	√	√	√

Figure 10 shows blue swimming crabs will experience peak season when the western monsoon season is over in mid-April. However, respondents' perceptions of small-scale fishing are usually still subjective due to their perceptions of various livelihoods [35].

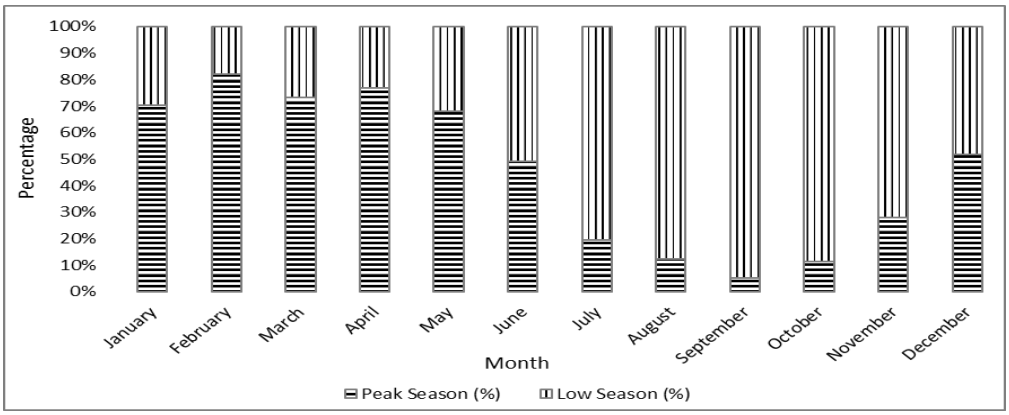

Fig. 10. Perception of Respondent to the Blue Swimming Crabs Fishing Season

In addition, the regulation of blue swimming crab capture zoning is also an effective way to recover the population of these fishery commodities, especially in the *zoea, megalopa*, and *adolescent* phases, which are critical phases of their growth and must be protected [36]. In general, the growth phase of blue swimming crabs occurs in May, September, and November [37]. In Western Australia, fishing restrictions to preserve mated pre-spawning female species from increasing stock availability apply during the winter [38].

From an economic point of view, figure 11 describes that the closing period can be considered based on three indicators: production volume, price, and value. High production, but not accompanied by an increase in production value, can be an early indication of the closing policy. Therefore, May and November to December indicate an early closing of the fishing season. Based on ecological, social, and economic aspects, the alternative period of the closed season is (1) May (1 month) and (2) November–December (2 months).

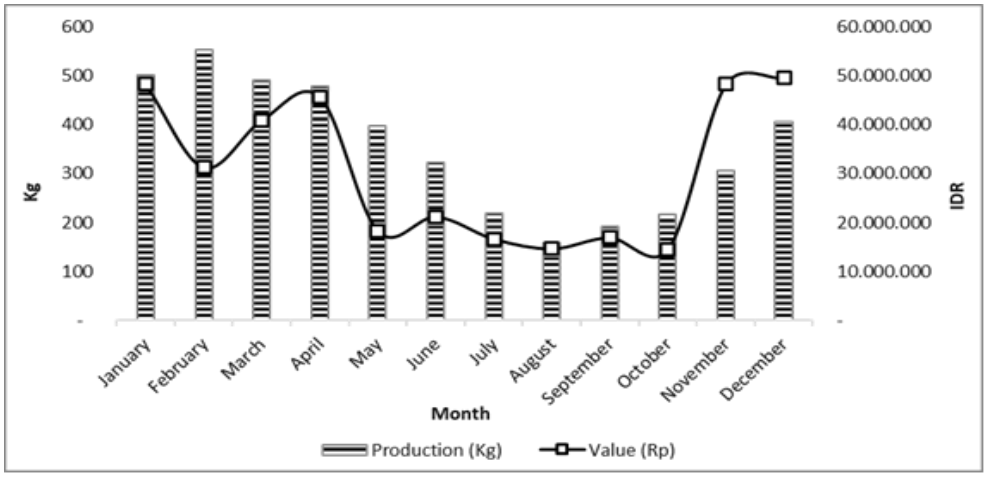

Fig. 11. Average Monthly production Volume and Production Value of Blue Swimming Crabs

The peak season of blue swimming crabs is different among research areas. According to *D.D. Kembaren et al.* [39], blue swimming crab larvae usually spread in coastal and offshore waters. This difference illustrates that the blue swimming crab's management policy must look at the pattern of the seasons in each area of the blue swimming crab's fishing area. Furthermore, peak season and off-season information are essential for analysing blue swimming crabs' production and value. For example, the production value and volume decreased from January to July. Meanwhile, the production volume and value increased from October to December.

Types of Fishing Gears and Fishing Ground

The utilisation of fishing gear in blue swimming crab management needs to consider two factors: i) the specifications and ii) the operational characteristics of the fishing gear. The principle of environmentally friendly and non-destructive fishing gear has become an absolute requirement in managing blue swimming crabs. The specification of fishing gear is also related to the importance of maintaining the quality of blue swimming crabs, crab meat, and the size of blue swimming crabs. The quality of blue swimming crabs and blue swimming crabs meat will significantly affect the selling price and export of blue swimming crabs, which have experienced a decrease in quality. The decline in the quality of blue swimming crabs' meat has led to blending it and not distinguishing it based on the type or part of the meat. As a result, the purchase of blue swimming crabs is currently at the same price (called "*root*").

There are four primary considerations for fishermen when utilising fishing techniques: the time of fishing, the fishing ground, the fishing gear, and the number of trips. Generally, a

fisherman in four research locations still uses modified, friendly fishing gear called an arad (mini trawl). They usually use two types of fishing gear in each boat, i.e., a collapsible trap (called *Bubu lipat),* an arad or collapsible trap, and a crab gillnet. Both fishing gears can be used simultaneously, considering *Bubu* is a passive fishing gear and it takes time to get results. While waiting, fishermen usually operate other fishing gear, such as an arad or gillnet. The location and time of fishing in one year are constantly changing. Crab fishermen usually temporarily move from one place to another (called *Andon*), depending on the season. For example, fishermen from Cirebon Regency move to Lampung or Muara Angke, and fishermen from Demak do *Andon* move to Cirebon or Lampung to catch blue swimming crabs due to the different peak seasons of crab fishing from all locations.

Consequently, the number of fishing trips constantly changes throughout the year. Fishermen are travelling a long distance to the fishing grounds each year because the stock of blue swimming crabs in the closer area is decreasing. As a result, fishermen must move offshore or to other sites to get maximum results in one fishing trip. In addition, crab fishermen are dependent on the rainy season and the dry season. Both seasons affected the number of catches. In the dry season, the yield obtained is relatively greater than in the rainy season. In the rainy season, fishermen cannot go to the sea because of the high sea waves. There are two types of crab fishing gear becoming less environmentally friendly or destructive: i) modified fishing gear, and ii) misuse of fishing lines. Both types of violations occurred at all research sites. Modified fishing gear is usually related to the size of the mouth-width of the fishing gear (scratching, *arad*), the mesh size (*gillnet*), the modification of ballast and wing materials (*arad*), the length of the rope, the excessive number of fishing gear (*Bubu*), and the misuse of fishing routes. The Minister of Maritime Affairs and Fisheries Regulation No. 18/2021 has regulated the operational location of each fishing gear. Violations of the fishing line are usually committed by fishermen who operate rake fishing gear in the Cirebon Regency area and *arad* nets in the Demak Regency area. These fishing gears are not allowed to be caught in the IA and IIA lines, but they still catch crabs in the area. As a result, there are conflicts between users of *arad* net fishing gear, *Bubu*, gillnets, and other fishing gear.

Therefore, arranging the crab fishing gear to support the governance model with an open-closed season approach needs to pay attention to four main factors, namely: i) regulation of fishing gear that is not environmentally friendly (referring to *PERMENKP* 18/2021); ii) sterilisation of fishing gear in the closed area during the closed season; iii) technical and operational standardisation of fishing gear; and iv) limiting the number of fishing gear per fishing fleet (e.g., *Bubu* max. 300 units; Scratch max. 3 units, etc.). In addition, the fishing grounds management should consider three main factors: i) the operation of fishing gear according to the fishing line (*PERMENKP* 18/2021); ii) the prohibition of the use of fishing gear in the closing zone during the closed season; iii) regulating the fishing area for each fishing gear. Figure 12 illustrates the different fishing gear operations in the fishing line area.

The supporting Rules

The consequences of the main rules, namely the closed area, fishing ground, and regulation of fishing gear, will have short-term impacts on both social and economic levels. This condition is very normal because the crab fishery is closely related to the small-scale fishermen dominating this fishery activity. Therefore, besides the main rules that must be obeyed in implementing the open-closed-season approach, the actions might be designed to support the implementation of the previously described rules. In this research, there are at least six additional rule support options for the open-closed season model, namely: a) facilitation; b) socialisation rule of the game; c) social safety net; d) incentive; e) market management; and f) supervision and law enforcement.

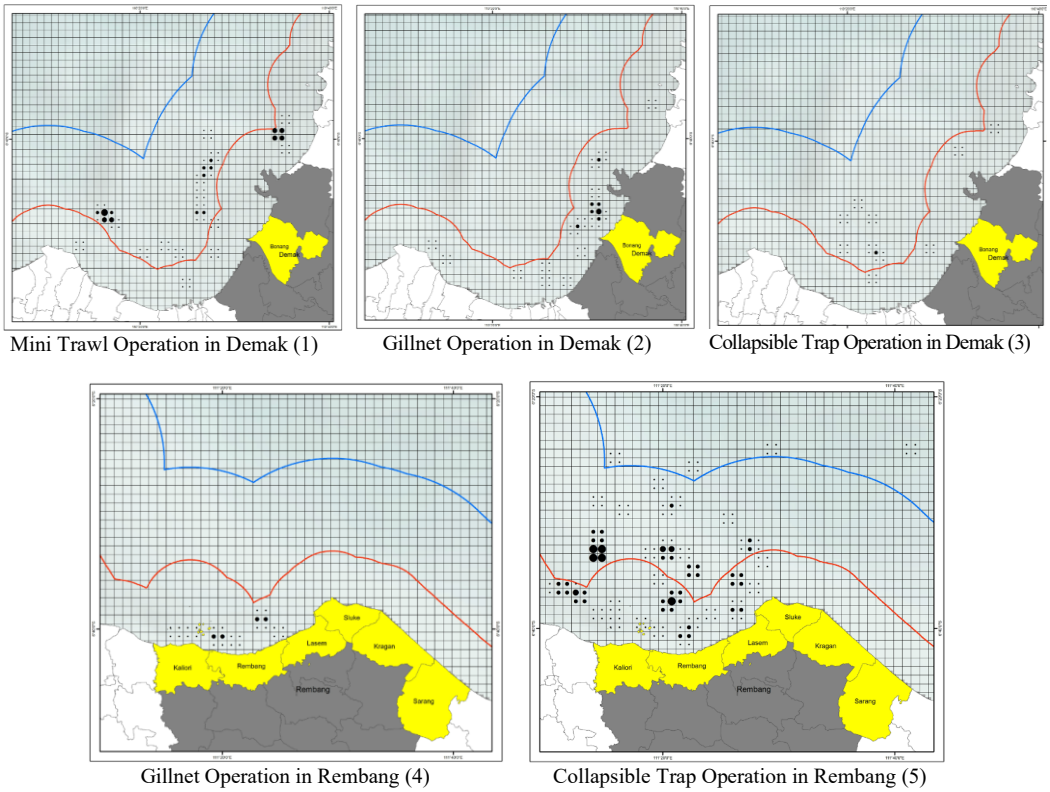

Fig. 12. Operational Pattern of Fishing Gears in Selected Research Area

Socialisation is proposing to introduce the procedure of open-closed seasons. Socialisation is also an alternative for community education tools, especially for fishermen and processors, to understand this open-closed management system and follow the rules of open-close season management. First, society and business actors must be given a logical and scientific understanding of all the rules to be implemented. Then they can participate in implementing the open-closed season of blue swimming crab fishing. There are at least three main topics that need to be conveyed to the community, namely: i) the existing rule of size limitation; ii) rules on fishing routes (referring to PERMENKP 18/2021); and iii) open-closed season methods and fishing grounds. This socialisation is carried out with educational methods and media that are easily understood by the poor community and all levels of education—in addition to establishing champions in each location to foster a spirit of mindset change and awareness in the community, especially blue-swimming crab fishermen.

Facilitation provides convenience to blue-swimming crab fishermen affected by the closed fishing season. In addition, facilitating business actors can ease licencing efforts for fishers who want to use fishing gear or other fisheries businesses. Facilitation for blue swimming crab fishermen affected by implementing the open-closed season can differ in each region depending on the character of the community, the area, fisheries activities in general, and the needs and preferences of fishermen. This facilitation is carried out to provide an alternative solution for fishermen, especially given the demands of daily life during the closed fishing season. However, in general, some of the facilitations expected by crab fishermen are: i) fishing aids (for example, fish aggregating devices (FAD), mussel cultivation farms); ii) community-based management institutions, especially for the management of conservation areas (closed areas); iii) alternative livelihoods for fishermen and fishermen's wives (crispy "baby crabs"

called "*gompel*" processing or processing other fishery products); iv) permits for the use of other environmentally friendly fishing gear; v) easy access to financial capital to start other productive businesses.

The incentive relieves business actors from staying afloat during the closing season of blue swimming crabs. Incentives can be given in the form of low-interest loans, providing daily food during the closing season, or providing other jobs. Incentives should be given to fishermen and business actors who comply with existing rules on fishing and post-harvest. In general, incentives help stabilise the crab fishing industry from upstream to downstream. Based on the results of the incentive analysis, three aspects can be allocated, namely: i) the price of blue swimming crab products must follow the size and quality of the product (price differentiation); ii) a guarantee of crab price stabilisation for fishermen; and iii) incentives for processors who produce crab meet according to the meet composition (no mixing).

The social safety net aims to ensure businesses remain economically safe and have family needs met. The safety net can be in the form of insurance or strengthening economic institutions (cooperatives, village business corporations, regional business corporations).

Market management aims to manage the market by synchronising market demand, especially from foreign markets, with the supply of blue swimming crabs. Decreasing the selling price phenomenon of crabs at the fisherman level often occurs when production is high while demand from foreign markets is low. Although the exporter bought crabs from fishermen then, the price set was lower.

On the contrary, when demand from foreign markets is high, the production of catches is low. Therefore, it is necessary to synchronise demand and supply in the market aspect to improve the quality and awareness of fishermen. Based on the phenomenon that has occurred so far, three treatments need to be carried out, namely: i) control of export permits for synchronisation with the spawning season; ii) quality control, especially in the process of selecting more particular crab products with minimal size and stripping processes; and iii) control of purchases at all nodes of the supply chain. These three treatments need mutual understanding and agreement between the government, crab meat exporters, processors, and fishermen. Furthermore, supervision of misappropriation behaviour by individuals also needs to be carried out strictly, especially on the quality of crabs and their meat.

Surveillance and Law enforcement are critical factors in determining the success or failure of model implementation. However, community compliance is still low, which has caused the implementation of policies to regulate the blue swimming crab fishery to encounter many obstacles in the field. In quantity, the supervisory officer still does not control all the district and provincial water areas simultaneously. Furthermore, people tend to be disobedient if there is no supervision from officers in the field, and vice versa. Therefore, supervision and law enforcement focus on two operational and technical activities of fishing: i) Periodic patrols and supervision during fishing activity (independent or combined); ii) The central government, local government, and police increase budget allocations for supervision and law enforcement. Meanwhile, the Ministry of Marine Affairs and Fisheries and the Food and Drug Supervisory Agency (BPOM) need to supervise the post-harvest process up to the final product (canned crab meat) to maintain the quality of crab meat. Implementation of four supporting policies is optional, according to the specific climatic and socioeconomic conditions. However, this policy is essential to maintaining a crustacean-type population, especially by ensuring compliance at every level of its value chain [18].

Sustainability of Fishermen's Livelihood Activity

The data collection results successfully identified all indicators in five capitals. From the results of the *iKERT* calculation, the Human Index is the highest, and the natural and physical indexes have the lowest values. Urgency *iKERT* is based on the location of the research sample to get a comparison between sites. That way, learning between each area can be known, among others, through differences in the status of *iKERT* in each location. For example, the sampling

location in Rembang Regency has the highest iKERT because it has natural capital, human capital, and a relatively high financial index. In contrast, Demak Regency, which obtained the smallest index, was caused by several physical, human, and social indexes. Variables that affect it include access to transportation, production inputs, community participation, compliance with rules, conflict, health, and education.

The Marine and Fisheries Household Economic Sustainability Index has described marine households' economic sustainability. This index used weighing factors and scores to get the value of the marine household sustainability index (Table 1). The number of weighings is in the range of 0 to 1, with the total number of weighings equal to one. The total number of these weighing numbers follows the rules of priority weights *(Eigenvalue Method)*. The range score of 1–3 is from various inputs. For example, focus group discussion (FGD) with community leaders, researchers, and other sympathisers, literature, and expert information contribute to determining the score (Table 2).

Table 2. The results of the Measurement, Score, and Values of *iKERT*

Indicators	Variable	Weighing Numbers	Scores
Nature	Access to natural resources	0.10	3
	Status of fisheries resources	0.13	2
	Production season	0.07	3
Human	Level of education of household members	0.02	1
	Skills and knowledge improvement training	0.07	2
	Health conditions	0.08	3
	Age	0.01	3
Financial	The activities that provide income	0.09	3
	Amount of household income	0.08	3
	Access to government assistance programs	0.02	2
	Access to credit	0.02	2
	Amount and type of savings	0.05	2
Physical	Access to public transportation	0.03	2
	Access to essential services (education, health)	0.02	3
	Access to production inputs	0.07	3
Social	Participation and membership in the organization	0.04	2
	The existence of community groups and the degree of influence on social networks	0.05	2
	Rules, norms, or laws that positively or negatively impact community development	0.04	3
	Conflict (potential and actual)	0.03	2

Based on the number of balancers produced above, the fishery resource status variable becomes the highest weighing number (0.13), while the *age* variable becomes the lowest weighing number (0.01). Technically, the usefulness of this resulting balance number will be a parameter in the calculation of *iKERT*. The multiplication value of scores and balances will help make strategies towards the economic sustainability of marine households. *N. Stacey et al*. [2] stress that the development of livelihoods in coastal communities in Indonesia should consider gender aspects that can support the economic sustainability of households. As an example, in East Timor, 50% of women in coastal areas participate in fishing activities as a tool for fisheries management [40]. The data collection results successfully identified all indicators in five capitals. The indicator data used in index calculation is ordinal (showing only the order with the interval scales). The data inputted after going through the categorization process is as follows:
With Eigen analysis, the formula for calculating the index of five capitals is:

- Natural Capital Index, as follows:

$$IXA_i = 0{,}1\,XA1_i + 0{,}\,13\,XA2_i + 0{,}\,07\,XA3_i \quad \text{.....(1)}$$

- Human Capital Index, as follows:

$$IXO_i = 0.02\,XO1_i + 0.07\,XO2_i + 0.08\,XO3_i + 0.01\,XO4_i \quad \text{...(2)}$$

- Financial Capital Index, as follows:

$$IXU_i = 0.09\,XU1_i + 0.08\,XU2_i + 0.02\,XU3_i + 0.02XU4_i + 0.05\,XU5_i \ldots (3)$$

- Physical Capital Index, as follows:

$$IXFI_i = 0.03\,XFI1_i + 0.02\,XFI2_i + 0.07\,XFI3_i \ldots\ldots (4)$$

- Social Capital Index, as follows:

$$IXSO_i = 0.04\,XSO1_i + 0.05\,XSO2_i + 0.04XSO3_i + 0.03\,XSO3_i \ldots\ldots (5)$$

The previously obtained balance is multiplied by all the initial data. Then, sum each multiplication result according to formerly known indicators and normalise the Index for Natural, Human, Financial, Physical, and Social Capital and Total *iKERT* $(X_i - Xmin)/(X_{max} - X_{min})$.

Figure 13 describes the results of the *iKERT* calculation: the Financial Index is the highest (58.77), and the Human Index has the lowest value (25). That way, learning between each location can be known, among other things, through differences in the status of *iKERT* per location. In the case study in Banten, Indonesia, the sustainability index value is 59.97%, which means that the deal is enough to assess the sustainability of blue swimming crab fishing activities in the region [41]. The results of *the iKERT* calculation depend on the sampling location, as shown in Figure 14. Nevertheless, *Y. Liu and Y. Xu* [42] argue that every household should adopt the overall existing capital for livelihood sustainability.

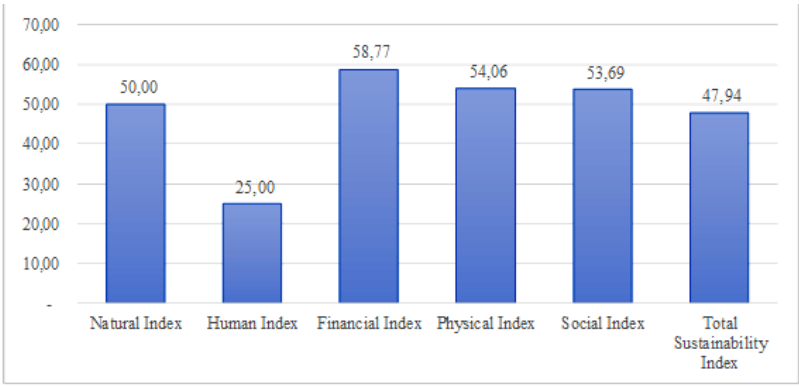

Fig. 13. Household Economy Sustainability Index of Blue Swimming Crab Fishers according to the Five Dimensions of the *iKERT*

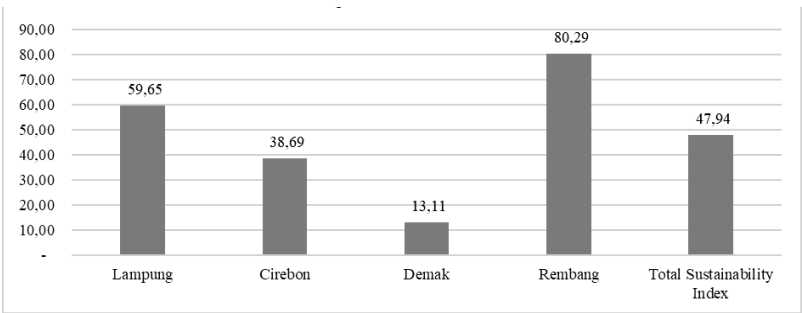

Fig. 14. Household Economic Sustainability Index by *iKERT* Research Locations

Sampling locations in Rembang are the locations with the highest *iKERT*. The variables that make up the high value of *iKERT* in Rembang are the natural capital index, human index, and relatively high Financial Index. The variables of natural capital consist of the amount of

access to natural resources and the status of fishery resources. The human index variables include age, education level, and health access. In addition, variable income, activity, and savings contribute to the financial index in Rembang Regency.

In contrast, Demak is the smallest index caused by several physical, human, and social indexes. Variables that affect it include access to transportation, production inputs, community participation, compliance with rules, conflict, health, and education. As suggested by *D.J. Mills et al.* [43], interventions are thinking about fishermen and the seriousness of coastal communities that also have vulnerabilities to food needs and income from natural resources. Based on the results of *iKERT*, the human index is the highest, and the natural and physical index has the lowest value. Some things that make the value *of iKERT* Rembang high are the natural capital index, the human index, and the relatively high financial index. The variables that support the high index of natural capital are the amount of access to natural resources and the status of fishery resources. The human index variables are age, education level, and health access. In addition, variable income, activity, and savings contribute to the financial index in Rembang Regency. In contrast, Demak, who obtained the smallest index, is caused by several physical, human, and social indexes. Variables that affect it include access to transportation, production inputs, community participation, compliance with rules, conflict, health, and education.

Figure 15 shows that the respondents' dependence on fishery resources in general and blue swimming crabs is still relatively high, especially in the Demak, Cirebon, and Rembang regions. Menurut *U. Untari et al.* [44] state that increased dependence on fisheries can make fishermen's income vulnerable because the seasons greatly influence them. In this research, the different distinctive characteristics of fishermen have made them unable to work in sectors other than fisheries, especially during the famine season. However, there is an opportunity for developing green mussel cultivation in coastal areas, especially in the surrounding Demak and Cirebon coastal areas, where only a small number of fishermen carry out these activities as an alternative livelihood. The cultivation of green mussels can be carried out all year. It is an excellent opportunity for an alternative household economy, such as the role of seaweed cultivation for fishermen in Laikang Bay, South Sulawesi, which became the primary income [45, 46]. It would change the trend of livelihood activity in agriculture and fisheries [47].

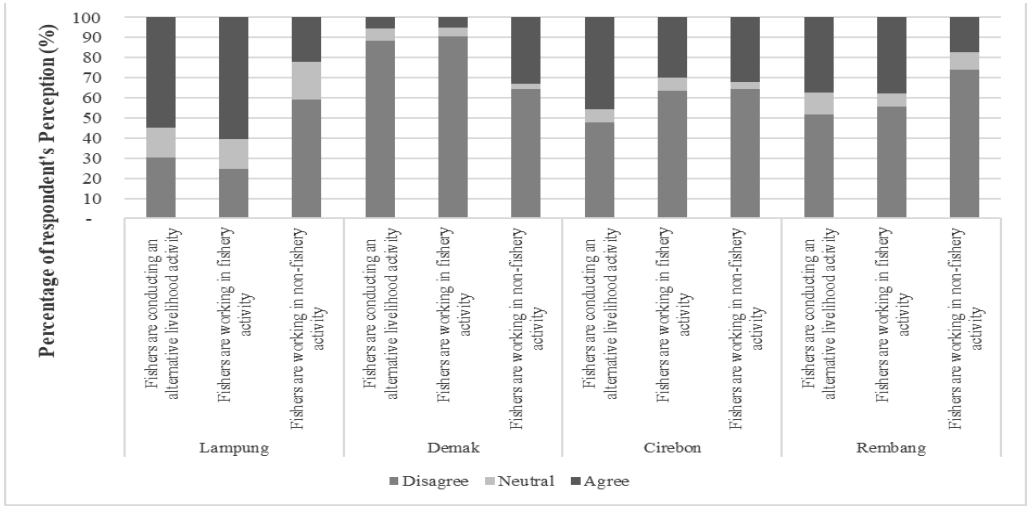

Fig. 15. Respondent's perception of alternative livelihoods during a closed season

Fishermen prefer to stay in their area to repair boats or keep fishing despite getting little results. Activities that can be an alternative job during the closed *season* of blue swimming crab

fishing are directing fishermen to catch fish using other fishing gear. Fishermen often operate the fishing gear they have throughout the year to earn income [3]. During this time, fishermen use *arad* to catch blue swimming crabs and fish throughout the year, even though there is no season for blue swimming crabs. The tool also detects blue-swimming crabs while simultaneously catching fish with the target species. Therefore, the fishermen need to improve their education and existing rules. The respondents highly depend on blue swimming crab fishing, especially in the Demak, Cirebon, and Trembling regions. Their distinctive character has not allowed them to work in sectors other than fisheries, especially during the famine season. As a result, fishermen prefer to stay in their area to repair boats or fish, despite getting little results. The reduction in capture efforts decreased the number of blue swimming crabs in the short term but showed an increase in production over time. Fishermen naturally carry out the situation and indirectly improve the environment, which has been proven in Thailand in fishing mitigation [48]. Therefore, the dynamics of changes in fishing income or income from blue swimming crab capture efforts show the same pattern as the dynamics of total production.

Table 3 explains the investment feasibility analysis of blue swimming crab fishing activity against two management scenarios (with or without an open-closed season approach). The table shows that the business activity is feasible because each calculation meets the investment criteria. However, the value of the benefits that will be obtained is two times greater if the open-closed-season approach is chosen to be implemented. In the short term, the open-closed-season approach is feasible for fishermen's welfare and fair for business actors. Meanwhile, the long-term plan will affect sustaining blue swimming crab resources. A study by *P. Huang et al. [49]* describes how combining long-term fishing seasons for male crabs with short-term fishing seasons for female crabs can sustainably increase yields and incomes.

Table 3. The result of Blue Swimming Crab Business Feasibility within Two Scenarios

No	Feasibility Analysis	1st Scenario – with Open-Closed Season	2nd Scenario – without Open-Closed Season (Existing)
1	NPV Cost	256.528.526.758,78	58.688.819.245,25
2	NPV Benefit	71.366.393.217,97	36.711.047.316,00
3	B/C Ratio	3,59	1,60

Implementing an open-closed-season approach for future blue swimming crabs requires comprehensive institutional support from upstream to downstream. These institutions include crab production, supervision, finance, and marketing. *V. Owusu, E. Andriesse* [19] state that all resource users, state agencies, and NGOs also need inclusive communication to collaborate on marine resource management. The proposed institutional scheme so that the open-closed season model can run to maintain the sustainability of blue swimming crab resources, business fairness for business actors, and business sustainability requires the role of actors *C. Warren and D.J. Steenbergen* [50] remind us that the government's failure to control fishing is a cause of the local economic problems that are challenging to solve.

Conclusions

The activities that can be an alternative job during the closed season of blue swimming crabs are directing fishermen to catch fish using other fishing gear. The calculation of investment feasibility of blue swimming crabs captures business against two management scenarios (with or without OCS), showing that blue swimming crabs capture business activities worth running because each calculation meets investment criteria. However, the benefits' value is two times greater if the OCS policy is better applied. It means that the OCS policy is feasible for short-term goals, namely fishermen's welfare and business justice for business actors, and for long-term goals, namely the sustainability of blue swimming crabs.

Implementing the blue swimming crab's management model with the OCS approach requires comprehensive institutional support from upstream to downstream. The institution starts with institutional production, supervision, finance, and marketing of blue swimming crabs. Institutional schemes are proposed so that the OCS model can run to maintain the sustainability of Blue Swimming Crab's resources, fairness of effort for business actors, and business sustainability, which require the actor's role.

In conclusion, this concept of OCS's model provides various scientific simulations for this specific research location. However, this cannot be generalised to other places, especially those with different socioeconomic and environmental characteristics from the current research location.

Acknowledgments

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