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Bioeconomic Analysis of Mud Crab (Scylla Spp.) in Kendal Regency Sea Waters

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A B S T R A C T

Mud crab (Scylla spp.) production in Kendal Regency's capture fisheries has risen, it tends to risky mud crab stocks and overfishing if resource extraction surpasses capacity. This study aims to assess production, fishing effort, and bioeconomic status of mud crab (Scylla spp.) in Kendal Regency. Respondents collected with snowball method. Data gathered by observation and interviews. The study applied bioeconomic analysis with Schaefer Logistic Growth Model approach. Maximum Sustainable Yield (MSY) was estimated at 19,245.7 kg from 5,223 fishing trips, while Maximum Economic Yield (MEY) was 18,878 kg from 4,501 trips. The equilibrium open access level was 9,169 kg from 9,003 trips. Optimal profit for mud crab utilization was Rp. 2,142,714,620.00 under MEY, Rp. 2,087,605,830.00 under MSY, and zero under Open Access Equilibrium (OAE). Currently, mud crab (Scylla spp.) utilization in Kendal Regency is fully-exploited, with allowable utilization of 19,246 kg, utilization percentage of 88%, and exploitation percentage of 87%. To sustain the mud crab fishery, stakeholders should responsibly manage crab resources exploitation.

Keywords: Bioeconomic, Mud Crabs, Utilization, Kendal Regency Sea waters

1. Introduction

The genus Scylla can find across the Indo-West Pacific. The mud crab mostly lives in estuarine area and sheltered coastal habitats. Large population of mud crab is one of the marine biotas associated with mangrove forest areas in tropical climates, especially in coastal areas influenced by tides. The widest distribution so far recorded in Western Indian Ocean, Japan, and the Pacific islands. And extending into Indian Ocean, South China, and Java Seas (Le Vay, 2001).

Mud crab (Scylla spp.) fishing in the waters of Kendal Regency is exploited with folding trap (bubu) and gillnet fishing gear. The number of trips for both gears increase every year. Kendal area is one of the areas located on the North Coast of Java. The operations of these fishing gears in Kendal waters (Java Sea) has a destructive impact on the environment of mud crab habitat, namely at the seafront with muddy substrate texture and mangrove ecosystem areas starting from the landward zone which has the ability to accumulate high organic matter so that enough food is available for coastal organisms. Fishing activities must be carried out with attention to its environmental friendliness to the impact given to the ecological sea waters must be minimized. The fleet of vessels carrying folding traps and gill nets is 1-5 GT. Mud crabs (Scylla spp.) are animals that have a wide distribution area and are able to adapt strongly to mangrove forests. This is because mud crabs (Scylla spp.) have a high tolerance to abiotic factors, especially salinity and temperature. The existence of marine biota species such as crabs can be found on all beaches that are influenced by tides and have a variety of environmental variations from mangrove forests (Gita, 2016).

Based on the type of mud crab caught, the size of mud crab caught, the economic value of the catch, the placement point of fishing gear and the impact of long-term use of fishing gear will help control mud crab resources in Kendal District. According to Suman et al. (2016), over utilization status reached 63% of the Penaeid shrimp, lobster, and crab groups in all Fisheries Management Areas (FMA) except FMA 717. The continued capture of mangrove crabs (Scylla spp.) to meet the high market demand in Kendal without any regulation can lead to the possibility of declining crab populations. So, it is important to find out the mud crab fishing status in Kendal Regency.

2. Research Method

2.1 Types and method of data collections

The type of data used in this research is primary data which was data obtained directly from the main source through interviews, observation and documentation. The data includes business investment, production costs, depreciation costs, catch weight, fishing production value, fishing fleet, fishing

area, and fishing gear operation methods. Secondary data related to this study include data on the number of fishing fleets, number of fishing gear, number of fishermen, total production and production value, especially mud crabs (*Scylla spp*) in Kendal Regency for the last 5 years, starting from 2017 to 2021. The data collection methods used in this research are observation method, interview method, documentation method, and literature study method. The data collection method used is *snowball sampling*. According to Sugiyono (2013), snowball sampling is a sampling technique that is initially small in number, then enlarged. At first the number was small, but the researcher found incomplete with the data provided by the sample, so the researcher search for other respondents that were considered to be able to complete the data.

2.2 Data analysis method

Data analysis was used the CPUE standardization method by determining the *Fishing Power Index* (FPI) value of the trip value of the two-fishing gear, namely folding trap (bubu) and gill net. Folding traps have a higher productivity level of mangrove crab fishing than gill nets, thus the FPI value is equal to 1 (one) to become the standard of fishing gear to be standardized, in this case is the gill net. The next step, calculated fishing gear CPUE value will be used to calculate the fishing gear FPI value used as the standard of fishing gear. According to Zain *et al*. (2022), the FPI value can be obtained through the equation:

$$CPUE_r = \frac{Catch\ (r)}{Effort\ (r)} \quad (1)$$

$$CPUE_s = \frac{Catch\ (s)}{Effort\ (s)} \quad (2)$$

$$FPI_i = \frac{CPUE\ (r)}{CPUE\ (s)} \quad (3)$$

Whereas:

CPUE r = total catch per fishing effort of the gear being standardized

CPUE s = total catch per fishing effort of the gear being standardized

FPI_i = fishing power index of the i gear

Next, to determine the standardized fishing effort with the following formula:

$$Fs = FPI_i \ x \ f_i \quad (4)$$

Standardized fishing effort as Fs and fishing effort to be standardized as *f*i. After calculate the Standard CPUE value then conduct a Bioeconomic analysis with the Gordon Schaefer Model approach. This model has three equilibrium conditions, namely Maximum Sustainable Yield (MSY), Maximum Economic Yield (MEY), and Open Access (OA) conditions. According to Wijayanto *et al.* (2016), the formula used to calculate the three conditions of the Gordon Schaefer equilibrium can be seen in Table 1 below.

Table 1 - Gordon Schaefer Bioeconomic Analysis Formula.

Variables	**MSY**	**MEY**	**OAE**
Catch Yield (C)	$\alpha /4\beta^2$	αEMEY - β(EMEY)2	αEOAE - β(EOAE)2
Capture effort (E)	α/2β	(pα - c)/(2pβ)	(pα - c)/(pβ)
Total Revenue (TR)	CMSY. P	CMEY. p	COAE. P
Total Expenses (TC)	c.EMSY	c. EMEY	c. EOAE
Profit (π)	TRMSY – TCMSY	TRMEY - TCMEY	TROAE - TCOAE

Source: Wijayanto *et al*. (2016)

Whereas: α = *Intercept;* β = *slope;* p = fish price (Rp/kg); c = cost per capture attempt (IDR/trip)

3. Result and Discussion

3.1 Research location

Kendal Regency is one of the coastal areas in the northern waters of Central Java. The geographical location of Kendal Regency is located at 109º 40'-110.18" East longitude and 6º 32'-7.24" South latitude with an overall area of approximately 1,002.23 km^2 or 100,223 hectares with an altitude above sea level ranging from 4-641 m. The boundaries of Kendal Regency are the northern part bordering the Java Sea, the eastern part bordering Semarang City, the southern part bordering Semarang Regency as well as Temanggung Regency, and in the western part bordering Batang Regency. The potential of fisheries in Kendal Regency is very high so that it has considerable opportunities for the people of Kendal Regency to be able to manage capture fisheries resources and must be managed efficiently so that fish resource stocks in Kendal Regency remain sustainable and sustainable. The production and production value of mud crabs (*Scylla* spp.) landed at the Bandengan fish landing base, the lowest production of mud crabs occurred in 2019, namely

11.12 metric tons and on the other hand the highest production occurred in 2017, with total 22.5 tons. The highest production value occurred i n 2017 with a value of 3,373,530,093.00 IDR.

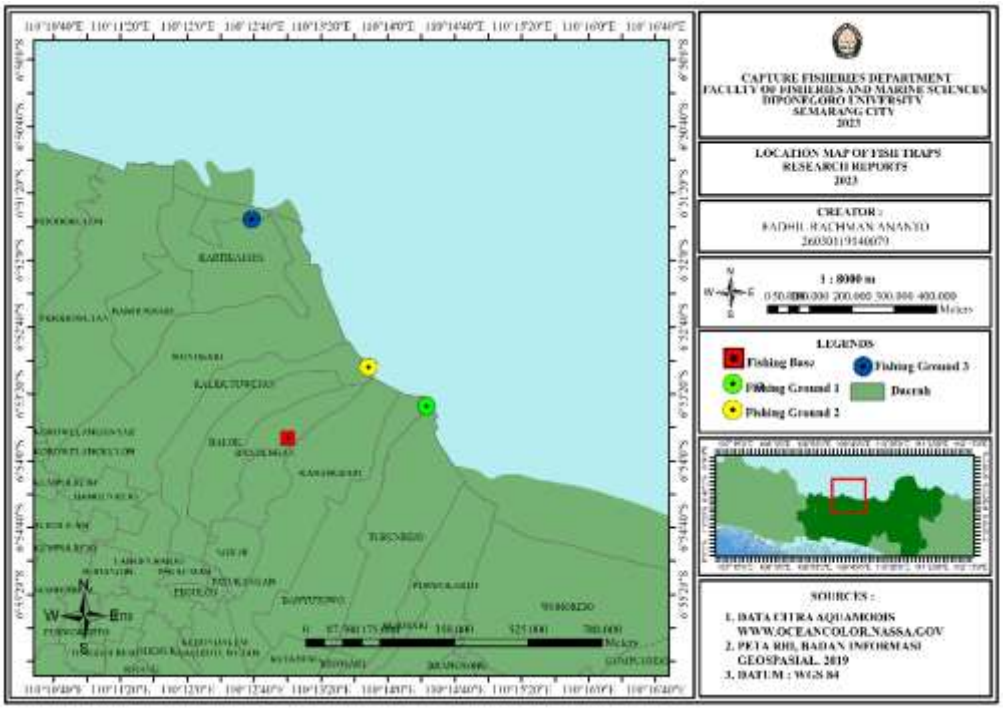

Fig. 1- Research Location

3.2 Mud Crab (Scylla spp.) fishing captured in Kendal Regency

The fishing fleet in Kendal Regency has a very large and diverse number because Kendal Regency has a large capacity of vessel capacity. The fishing fleet in Kendal Regency is differentiated based on the GT size category of the vessels. From 2017-2021, Kendal Regency is dominated by motor boats under the size of 5GT. The dominance of vessels <5GT is because the majority of fishermen are traditional using arad (mini trawl), bubu (folding trap) and gillnet which are only operated by artisanal fishers.

Table 2 – Fishing Gear Unit in Kendal Regency.

Year	Fishing Gear (Unit)		Total
	Folding Trap	Gillnet	
2017	6.392	126	6518
2018	5.293	138	5431
2019	1.527	144	1671
2020	3.982	160	4142
2021	4.514	160	4674

Source: Research Result, 2022

The fishing unit used to catch mud crabs in Kendal Regency use folding trap and gillnet fishing gear. Based on the table 1, shown that the number of trips of folding trap and gillnet fishing gear fluctuates every year. The highest number of trips of folding trap gear was 6,392 units in 2017 and the highest number of gillnet was 160 units in 2020.

3.3 Catch Per Unit Effort (CPUE)

Catch per Unit (CPUE) *Effort* is the determination of the value of the amount of catch per unit effort. Crab (*Scylla* spp.) resources are captured with more than one fishing gear, namely folding trap and gillnet, it is necessary to standardize fishing gear to equalize the standard value of the most active fishing gear when operating in fishing expedition. Standard fishing gear is considered from the largest CPUE value. The folding trap as the standard fishing gear with the largest CPUE value compared to other fishing gears were summarized in Table 3. Changes in the trend value of mud crab (*Scylla* spp.) CPUE in Kendal sea waters can be seen in Figure 2.

Table 3 – Standardize CPUE.

Year	Standardize of Trips/season		Production	Standard Effort Total	Standard CPUE
	Folding trap	*Gillnet*	Total (Kg/Year)	(Trip/Year)	(Kg/Year)
2017	1	2,109	22.504	6651	3,38
2018	1	0,894	18.134	5584	3,25
2019	1	1,208	11.125	1656	6,72
2020	1	1,241	15.572	4175	3,73
2021	1	2,109	17.427	4712	3,7

Source: Research Result, (2023)

Based on the Table 2., it is known that the CPUE value fluctuates. As a result of data processing, it is shown that the lowest CPUE value occurred in 2018 where the CPUE value was 3,247 kg/trip with a capture effort of 5,584 trips and a production yield of 5,000 kg/trip. The highest CPUE result occurred in 2019 where the CPUE value was 6.72 kg/trip with a fishing effort 1,656 trips and production of 11,125 kg. According to Wurlianty *et al.* (2015), the decline in CPUE value in a certain year period is caused by the increasingly distant fishing are as well as the influence of changes in natural conditions such as weather, wind, salinity, and season on the population and community of fish resources. Based on the Fig 3., it can be seen that the regression analysis results in a linear equation CPUE has negative correlation with total fishing effort. And significantly decrease the total catch per fishing trip with an R^2 value of 0.8327. According to Yuliana *et al.* (2016), the increasing trend of CPUE indicates that the utilization of fish has not been maximized so that efforts can still be increased. Increasing fishing effort must pay attention to the CPUE of each fish species because not necessarily increase.

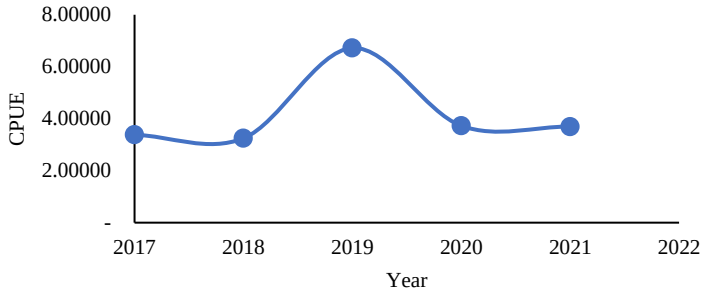

Fig. 2- Trend of Standardize CPUE

Source: Research Result, (2023)

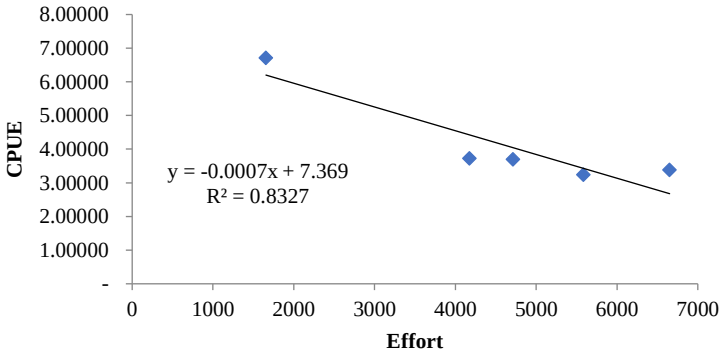

Fig. 3 - Correlation between Standard CPUE and Standard *effort of* mud crab (*Scylla* spp.) in Kendal Regency 2017-2021

Source: Research Result, (2023)

3.4 Bioeconomic analysis of Gordon Schaefer model

The fishing exploitation of mud crab is explored by several fishing gears that target the same type of catch requires standardization of fishing gear against standard fishing gear, so that the comparison of fishing power index will produce Standard CPUE and the results of MSY (Maximum Sustainable Yield), Maximum Economic Yield (MEY) and Open Access Equilibrium (OAE) conditions. The results of the calculation using the Gordon Schaefer bioeconomic analysis method can be seen in Table 8.

Table 4 - Standardized FPI and CPUE values of Crab Fishing Gear (*Scylla* spp.) in Kendal Regency waters.

Variables	MSY	MEY	OAE
Catch (Kg/year)	19,245.71	18,878.09	9,169.12
Effort (Trip)	5,223	4,502	9,003
TR (Rp/Year)	2,885,085,833	2,829,977,043	1,374,524,846
TC (Rp/Year)	797,480,003	687,262,423	1,374,524,846
Profit (π)	2,087,605,830	2,142,714,620	0

Source: Research Result, (2023)

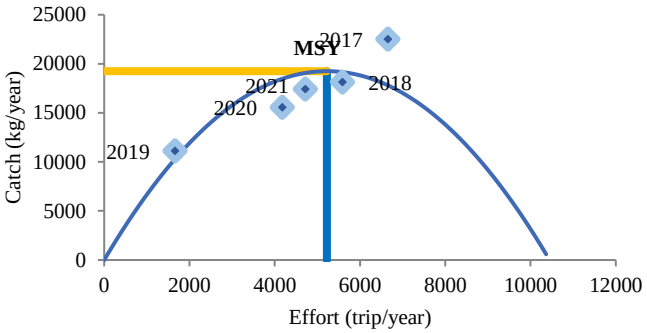

Fig. 4 – Bioeconomic Equilibrium Point of Gordon-Schaefer model of mud crab (*Scylla* spp.) in Kendal Regency

Source: Research Result, (2023)

Bioeconomic analysis the MSY condition reaches its equilibrium point at a catch of 19,245.71 kg/year and an effort of 5.223 times a year with a profit of 2,087,605,830 IDR. If fisheries utilization is in accordance with current conditions, the estimated risk value will be at a high-risk level, as well as if the utilization level is at its MSY value (Zamroni et al., 2020). MEY conditions are obtained when the catch is 18,878.09 kg/year and 4,502 fishing *efforts* are gain with a profit of 2,142,714,620.00 IDR annually. OAE conditions in the state of catch (C_{OAE}) calculated 9169 kg / year with the result of effort amounting to 9,003 trips per year.

4. Conclusions

The bioeconomic conditions of mud crabs (Scylla spp.) in Kendal sea waters predicted by Gordon Schaefer model is 19,245.7 kg/year with effort maximum 5,224 trips for sustainable yield condition (MSY). Meanwhile, the maximum economic yield (MEY) equilibrium is 18,878 kg/year and effort obtained 4.501 fishing trips/year. The profit obtained from MEY equilibrium is higher than MSY equilibrium. It is a kind of reference for mud crabs fishing exploitation. And to protect the mud crab sustainability, it must be avoiding higher fishing trips exploitation in open access regime. This condition tends to drive the zero profit of fishing commercial business.

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