



RENTE EKONOMI DAN TINGKAT UPAYA OPTIMUM PERIKANAN RAJUNGAN (*PORTUNUS SPP.*) DI WPP 712 (STUDI KASUS: PPN KARANGANTU BANTEN)

ECONOMIC RENT AND OPTIMUM ALLOCATION OF BLUE SWIMMING CRAB (*PORTUNUS SPP.*) IN FISHERY MANAGEMENT AREA 712 (CASE STUDY: PPN KARANGANTU, BANTEN)

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ABSTRAK. Rajungan (*Portunus spp.*) merupakan komoditas perikanan demersal bernilai ekonomi tinggi di Indonesia, namun peningkatan tekanan penangkapan mengancam keberlanjutan stok perikanan di lokasi tersebut. Penelitian ini bertujuan menganalisis tingkat pemanfaatan, menentukan upaya optimum, dan mengestimasi rente ekonomi perikanan rajungan di Pelabuhan Perikanan Nusantara (PPN) Karangantu, Banten dalam Wilayah Pengelolaan Perikanan 712. Pendekatan bioekonomi menggunakan algoritma *Clark-Yoshimoto-Pooley* (CYP) diterapkan pada data time series 2015-2024. Hasil penelitian menunjukkan Estimasi parameter biologi menghasilkan laju pertumbuhan alami (r) = 8,54/tahun, koefisien daya tangkap (q) = 0,00053, dan daya dukung lingkungan (K) = 30,94 ton. Analisis bioekonomi menunjukkan kondisi aktual (produksi 86,5 ton, effort 12.283 trip, keuntungan Rp. 1.055 juta) telah melampaui tingkat optimum. Rezim *Maximum Economic Yield* (MEY) menawarkan skenario paling optimal dengan produksi 58,8 ton, effort 5.396 trip, biomassa 20,6 ton, dan keuntungan Rp. 1.573 juta, meningkat 49% melalui pengurangan effort 56%. Jumlah Tangkapan yang Diperbolehkan (JTb) ditetapkan sebesar 52,86 ton (80% MSY), dengan alokasi kuota: jaring insang tetap (45,20 ton), jaring hela dasar/dogol (3,87 ton), dan bubu (3,79 ton). Rekomendasi kebijakan meliputi pengurangan effort menuju 5.000-6.000 trip/tahun dan penerapan pembatasan *input-output* untuk pengelolaan rajungan berkelanjutan di WPP 712.

Kata kunci: Bioekonomi, *maximum economic yield*, *maximum sustainable yield*, rajungan.

ABSTRACT. Blue swimming crab (*Portunus spp.*) is a high-value demersal fishery commodity in Indonesia, yet increasing fishing pressure threatens its stock sustainability. This study aims to analyze the utilization level, determine optimum effort, and estimate economic rent of blue swimming crab fisheries at Karangantu Fishing Port, Banten within Fisheries Management Area 712. A bioeconomic approach using the *Clark-Yoshimoto-Pooley* (CYP) algorithm was applied to time-series data from 2015-2024. Results showed Biological parameter estimation yielded intrinsic growth rate (r) = 8.54/year, catchability coefficient (q) = 0.00053, and environmental carrying capacity (K) = 30.94 tons. Bioeconomic analysis revealed that actual conditions (production 86.5 tons, effort 12,283 trips, profit IDR 1,055 million) have exceeded the optimum level. The *Maximum Economic Yield* (MEY) regime offers the most optimal scenario with production of 58.8 tons, effort of 5,396 trips, biomass of 20.6 tons, and profit of IDR 1,573 million, increasing profit by 49% through 56% effort reduction. Total Allowable Catch (TAC) was set at 52.86 tons (80% of MSY), with quota allocation: set gill nets (45.20 tons), bottom trawls/dogol (3.87 tons), and pots/traps (3.79 tons). Policy recommendations include effort reduction towards 5,000-6,000 trips/year and implementation of *input-output* controls for sustainable blue swimming crab management in WPP 712.

Keywords: Bioeconomic, blue swimming crab, maximum economic yield, maximum sustainable yield.

1. Introduction

The capture fisheries sector, particularly the blue swimming crab (*Portunus* spp.) commodity, plays a strategic role as a provider of employment and a source of foreign exchange through canned meat exports (Dahuri *et al.* 2008). In Banten Province, Karangantu Archipelagic Fishing Port (PPN Karangantu) serves as the primary landing site, dominated by 6,768 small-scale fishing vessels (<5 GT) in 2024. However, crab production in this area has experienced sharp fluctuations, from its peak of 133.7 tons (2018) to a low of 77.5 tons (2020), amidst a significant surge in fishing intensity. The drastic increase in fishing effort, such as the rise in set gillnet trips to 16,151 trips and total vessel calls reaching 32,273 times in 2024, indicates high exploitation pressure in Fishery Management Area (WPP) 712, threatening the sustainability of these resources.

Previous studies have established a strong foundation regarding the biology and bioeconomics of blue swimming crab in Indonesian waters. Research in Banten Bay found a sex ratio dominated by males (1.73:1) and positive allometric growth patterns for both sexes (Mursyid *et al.* 2020). Additionally, a bioeconomic analysis in the same area revealed that the maximum sustainable yield (MSY) was 79,743.483 kg/year with an optimal effort of 3,670 trips/year, while actual effort far exceeded these thresholds, indicating biological and economic overfishing (Ihsan 2023). Furthermore, a national-level study confirmed that blue swimming crab fisheries generate high economic rents under MSY and Maximum Economic Yield (MEY) regimes, but yield no rent under open access conditions (Muawanah *et al.* 2018). Despite these insights, previous research has predominantly focused on single-species surplus production models without fully integrating the recent paradigm shift in Indonesian fisheries governance towards measured/quotabased fishing (Penangkapan Ikan Terukur – PIT) as mandated by Government Regulation No. 11 of 2023 and elaborated through Minister of Marine Affairs and Fisheries Regulation No. 7 of 2024 concerning the Management of Lobster (*Panulirus* spp.), Crab (*Scylla* spp.), and Swimming Crab (*Portunus* spp.). This policy transforms fisheries management from an input-control to an output-control system, setting harvest quotas for each vessel (KKP 2024; Trenggono 2024). Consequently, a significant gap remains in translating bioeconomic optimum reference points (e.g., MEY) into tangible input and output control policy instruments tailored to the dynamics of WPP 712. The novelty of this research lies in its explicit linkage of the CYP bioeconomic algorithm with the specific regulatory framework of PIT, providing a quantitative basis for determining allowable catch quotas and effort limitations per vessel category, thereby directly supporting the implementation of sustainable and measurable fisheries on the northern coast of Banten.

The open-access nature of fishery resources encourages overfishing due to the concentration of fishing effort (Gordon, 1954; Hardin 1968 in Wahyudin 2016) within the same zone under 12 nautical miles. This condition risks triggering biological and economic overfishing, where purely biology-based management (Maximum Sustainable Yield) is considered inadequate as it ignores economic variables such as operational costs and fisher behavior (Fauzi 2010; Clark 1992; Fauzi & Anna 2005). Therefore, a bioeconomic approach using the CYP algorithm is necessary to integrate biological and economic aspects simultaneously. This study aims to analyze the utilization rate of blue swimming crab resources, determine the optimum effort, and estimate the potential economic rent in WPP 712 to formulate sustainable management recommendations for the northern coast of Banten.

2. Method

This study was conducted from July to August 2025 using a descriptive method with a case study approach to analyze the status of Maximum Sustainable Yield (MSY), Maximum Economic Yield (MEY), and Open Access Equilibrium (OAE) in the blue swimming crab (*Portunus* spp.) fishing units in Serang City. The research focused on one-day fishing fleets operating set gill nets, bottom trawls/dogol, and

pots/traps, with landings at Karangantu Archipelagic Fishing Port (**Figure 1**). Primary data on operational costs, fishing gear specifications, prices, and profit-sharing systems were collected through observation and interviews with 30 respondents selected using convenience sampling from a population of 218 fishing units. Meanwhile, secondary data in the form of production statistics and fishing effort for the 2015–2024 period were obtained from relevant agencies (DKP, PPN Karangantu, Kesemen sub-district office.) to ensure the accuracy of the bioeconomic analysis at the study location.

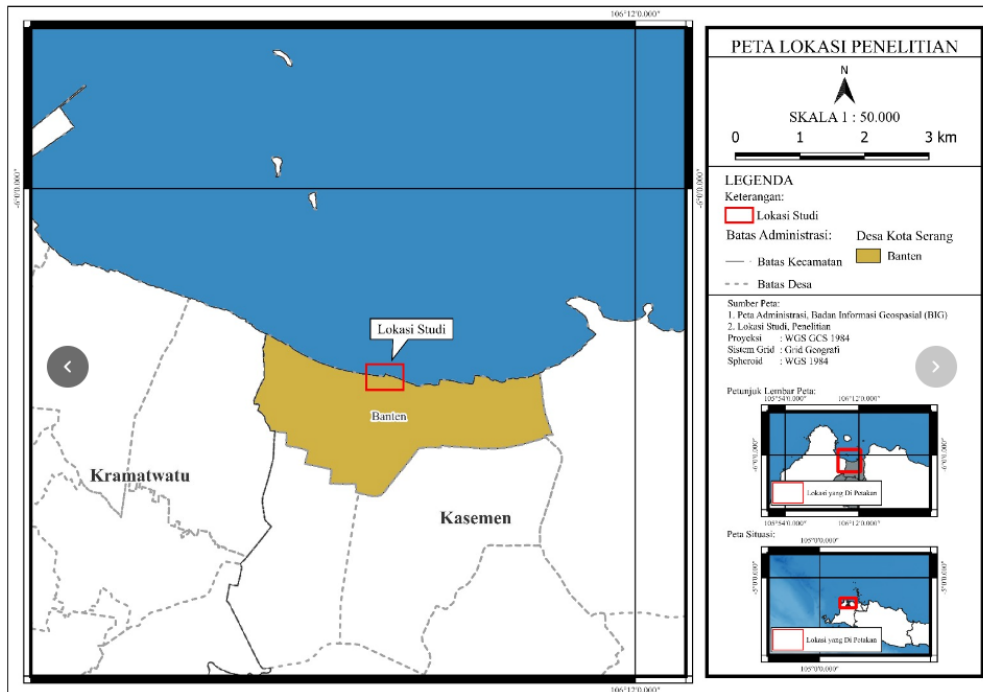


Figure 1. Research Location Map.

2.1 Data Analysis Method

To evaluate the exploitation status and economic sustainability of blue swimming crab fisheries, a quantitative approach integrating biological and economic indicators was required. The analysis focused on measuring fishing productivity over time and estimating optimal reference points that balance resource conservation with fisher profitability. This study used two main analytical instruments: the calculation of Catch per Unit Effort (CPUE) for fishing gear and the CYP bioeconomic model.

2.2 Determination of Catch per Unit Effort (CPUE)

The CPUE value was obtained by comparing the total production volume against the fishing effort intensity over a specific period. The basic formulation is:

$$CPUE = Catch / Effort \dots \dots \dots (1)$$

Where Catch is the total catch and Effort is the number of fishing vessels or fishing trips. Referring to Sobers (2010), the catch is a function of fishing effort and the available biomass size. Fishing effort (E) in this context was measured based on the number of fishing vessels operating per year. Subsequently, this production function was based on the Schaefer Surplus Production Model (1954) to estimate the Maximum Sustainable Yield (MSY) and Maximum Economic Yield (MEY) points.

2.3 Bioeconomic Analysis

To achieve sustainability, fisheries policy must be able to measure the value of resource rent through bioeconomic analysis. This analysis serves to measure economic potential while determining the optimal

utilization limit so that fishing activities remain sustainable (Wahyudin 2016; Dewantara *et al.* 2020). The implementation of the bioeconomic model in this study involved the estimation of biological and economic parameters.

In the biological aspect, fish stock growth is assumed to follow a logistic pattern involving biomass variables (x), carrying capacity (K), and natural growth rate (r). On the other hand, the fishing production function is influenced by effort intensity, stock availability, and fishing gear effectiveness or catchability coefficient (q) (Fauzi 2010). Based on these assumptions, the estimation of the production function was calculated using the following equations:

$$\frac{\partial x}{\partial t} = rx \left(1 - \frac{x}{K}\right) \dots\dots\dots (2)$$

$$h = qx E \dots\dots\dots (3)$$

Integration of the fishing effort variable into equations (2) and (3) using the Gompertz stock growth model (Anna 2003) yields the following equation formulation:

$$\frac{\partial x}{\partial t} = rx \left(1 - \frac{x}{K}\right) - qx E \dots\dots\dots (4)$$

Estimation of biological parameters (4) was then processed using the Clark, Yoshimoto, and Pooley (1992) algorithm method with the following procedure:

$$\ln(U_{t+1}) = \frac{2r}{(2+1)(2+1)} \ln(qK) + \frac{(2-r)(2-r)}{2+r} \ln(U_t) - \frac{q}{2+r} (E_t + E_{t+1}) \dots\dots\dots (5)$$

$$\ln(U_{t+1}) = \beta_1 + \beta_2 \ln(U_t) + \beta_3 (E_t + E_{t+1}) \dots\dots\dots (6)$$

The parameters r , q , and K were subsequently derived from the CYP algorithm calculation results in equations (5) and (6) using the following formulas:

$$r = \frac{2(1-\beta_2)2(1-\beta_2)}{(1-\beta_2)(1-\beta_2)} \dots\dots\dots (7)$$

$$q = -\beta_2(2 - r)q = -\beta_2(2 - r) \dots\dots\dots (8)$$

$$K = \frac{\exp \frac{\beta_1(2+r)\beta_1(2+r)}{2r}}{q} \dots\dots\dots (9)$$

Based on the biological parameter estimation above, the static bioeconomic formulas for the MEY, MSY, and OA management regimes are presented in **Table 1**.

Table 1. Bioeconomic Formulas.

Variabel	Management Regime		
	MEY	MSY	OA
Biomass (x)	$\frac{K}{2} \left(1 + \frac{c}{pqK}\right)$	$\frac{K}{2}$	$\frac{c}{pq}$
Catch/Harvest (h)	$\frac{rK}{4} \left(1 + \frac{c}{pqK}\right) \left(1 - \frac{c}{pqK}\right)$	$\frac{rK}{4}$	$\left(\frac{rc}{pq}\right) \left(1 - \frac{c}{pqK}\right)$
Effort (E)	$\frac{r}{2q} \left(1 - \frac{c}{pqK}\right)$	$\frac{r}{2q}$	$\frac{r}{q} \left(1 - \frac{c}{pqK}\right)$
Resources rent	$ph_{MEY} - cE_{MEY}$	$ph_{MSY} - cE_{MSY}$	$ph_{OA} - cE_{OA}$

Variabel	Management Regime		
	MEY	MSY	OA

$$(\pi)$$

Source: Fauzi (2004); Wahyudin (2005); Fauzi (2010); Wahyudin (2017)

Economic parameter estimation was performed by analyzing operational fishing costs and fish selling prices. Operational costs include all fisher expenditures per trip during fishing activities. Meanwhile, price parameters were obtained by converting nominal price data from the 2015–2024 period adjusted using the Consumer Price Index (CPI 2022) from BPS Kota Serang. Based on these parameters, the total sustainable revenue value was calculated using formulations (10), (11), and (12) according to Fauzi's theory (2004) as follows:

$$TC = cE \dots\dots\dots(10)$$

$$TSR = pqKE \left[1 - \frac{qe}{r} \right] \dots\dots\dots(11)$$

Based on the calculation results from equations (10) and (11), the economic rent value can be derived using equation (12) below:

$$TSR = pqKE \left[1 - \frac{qe}{r} \right] - cE \text{ or } \pi = ph - cE \dots\dots\dots(12)$$

Where, the TC = Total cost (Rp), p = Price (Rp), h = Production (Ton), E = Total effort (trip), c = Cost per effort (Rp), TSR = Total Sustainable Rent (Rp).

The fishing cost of blue swimming crab and the real price of blue swimming crab were calculated using the (13) and (14) following method (Fauzi and Anna 2005).

$$C_{riil} = \frac{C \text{ nominal}}{IHKt} \times 100 \dots\dots\dots(13)$$

$$P_{riil} = \frac{P \text{ nominal}}{IHKt} \times 100 \dots\dots\dots(14)$$

3. Result and Discussion

3.1 Blue Swimming Crab Production and Fishing Effort

Blue swimming crab production at Karangantu Archipelagic Fishing Port (PPN Karangantu) during the 2015–2024 period showed a fluctuating pattern with a long-term increasing trend, starting from 66.4 tons in 2015 to reach its highest peak of 115.57 tons in 2024, despite having experienced a lowest point of 40.79 tons in 2017. Along with these production dynamics, the standardized fishing effort increased significantly by more than threefold, soaring from 6,103 trips in 2015 to its peak of 21,775 trips in 2022, before finally being recorded at 19,982 trips in 2024 (Pelabuhan Perikanan Nusantara Karangantu 2019; 2024). This remarkable fishing intensification reflects the increasing exploitation pressure on blue swimming crab resources in Fishery Management Area (WPP) 712, where a drastic surge in effort has been observed since 2019.

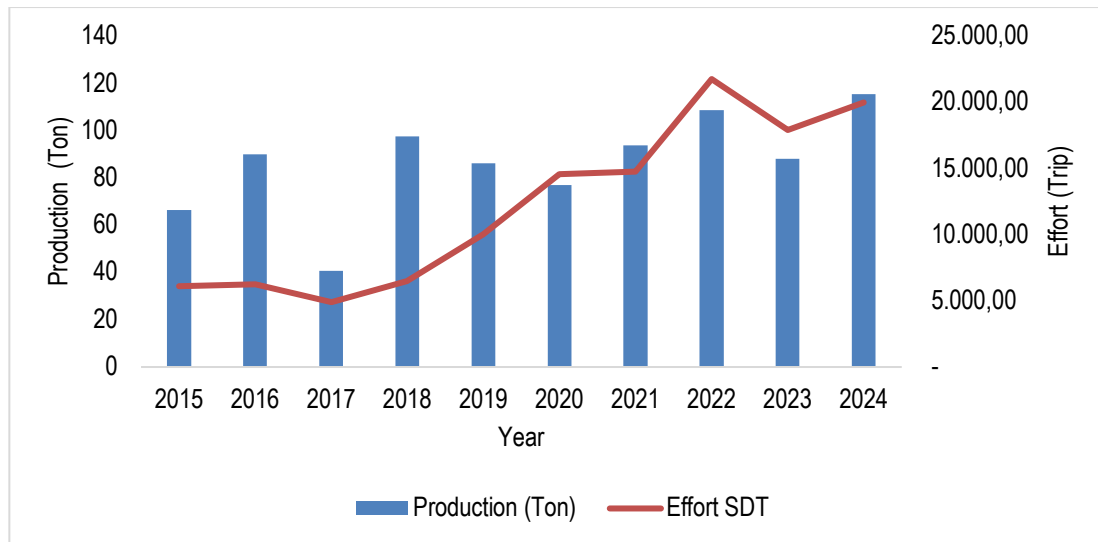


Figure 2. Blue Swimming Crab Production and Fishing Trips for 2015-2024 (Pelabuhan Perikanan Nusantara Karangantu 2019; 2024).

Table 2. Blue Swimming Crab Production, Standardized Fishing Gear Effort, and CPUE.

Tahun	Produksi (Ton)	Effort	CPUE
2015	66,433	6.103	0,0109
2016	90,193	6.257	0,0144
2017	40,788	4.904	0,0083
2018	97,557	6.495	0,0150
2019	86,254	10.042	0,0086
2020	77,043	14.577	0,0053
2021	93,951	14.752	0,0064
2022	108,823	21.775	0,0050
2023	88,083	17.938	0,0049
2024	115,568	19.982	0,0058

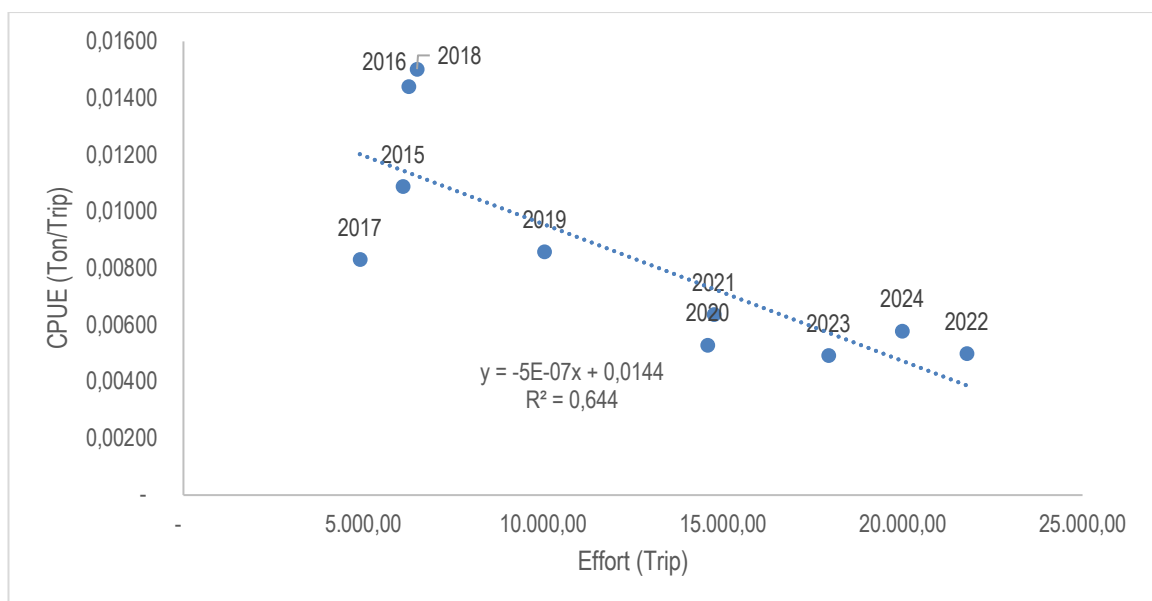


Figure 3. Relationship between CPUE and Effort.

Based on the analysis of the relationship between effort (trips) and CPUE (tons/trip), a linear regression equation was obtained:

$$y = -5E-07x + 0,0144 \text{ with diterminant } R^2 = 0,644$$

The regression equation shows an intercept of 14.4 kg/trip, representing the natural productivity of the waters before exploitation, and a negative coefficient of -0.0000005 tons/trip, confirming that each increase in fishing effort will consistently decrease the CPUE value. With a coefficient of determination (R^2) of 0.644, 64.4% of the CPUE variation is influenced by the amount of effort, while the remainder is determined by external factors such as oceanographic conditions and population dynamics. The historical trend during 2015–2024 reinforces this finding, where the early period (2015–2018) recorded high CPUE of up to 15.0 kg/trip when effort was still controlled, but then declined sharply to a low of 4.9 kg/trip in 2022 when effort soared to a peak of 21,775 trips. Although there was a minor improvement in 2024 to 5.8 kg/trip, the productivity level of these fishing units remains far below the early period conditions due to massive exploitation pressure.

3.2 Biological Parameter Estimation

The biological parameter analysis in this study was carried out by implementing the Clark, Yoshimoto, and Pooley (CYP) algorithm. This algorithm was used to estimate the natural growth rate (r), catchability coefficient (q), and biomass carrying capacity (K). The blue swimming crab stock estimation was based on annual time-series data including catch volume and fishing effort. Using the surplus production model, the relationship between Catch per Unit Effort (CPUE) and effort intensity from various fishing gears, such as set gill nets, bottom trawls/dogol, and pots/traps at Karangantu Archipelagic Fishing Port (PPN Karangantu), Serang City, was analyzed. The CYP model was chosen because it produces more accurate estimates compared to other surplus production models.

Table 3. Regression Results and Biological Parameter Estimation of Blue Swimming Crab using the CYP Algorithm.

Parameter Biologi Algoritma CYP	
Parameter	Biological Parameter Value
r	8,543758675
q	0,00052917
K	30,94
Statistical Tests	Statistical Value
Coefficient of Determination	0,8300
Adjusted Coefficient of Determination	0,7734
Regression F-Statistic	14,6573

Based on the Clark, Yoshimoto, and Pooley (1992) algorithm approach presented in Table 3, the estimation results show that the blue swimming crab has a high intrinsic growth rate (r) of 8.54 per year, reflecting a rapid recovery capacity but vulnerability to environmental fluctuations. The catchability coefficient (q) of 0.00053 indicates moderate technological efficiency. Meanwhile, the environmental carrying capacity (K) is estimated at 30.94 tons. This K value must be understood as stock biomass, not as an annual catch limit. In a fishery with a very high growth rate ($r = 8.54$), the stock can experience several turnovers per year, allowing the annual catch (as a flow) to exceed the stock biomass. For illustration, the annual growth potential is approximately $r \times K = 8.54 \times 30.94 \approx 264$ tons, while the sustainable yield (MSY) is calculated as $rK/4 \approx 66$ tons. Thus, actual production that has reached 86–115 tons is not biologically contradictory per se, although it has exceeded the sustainable limit (overfishing).

3.3 Economic Parameter Estimation

Economic parameter estimation was performed by analyzing real costs and real prices that had been adjusted using the Consumer Price Index (CPI) with 2022 as the base year. Details of the utilization of blue swimming crab fishery resources are comprehensively presented in **Table 4**.

Table 4. Economic Parameter Estimates.

Year	Consumer Price Index (CPI)	Real cost (Million/trip)	Real price (Million /Ton)
2015	0,251	0,251	41,281
2016	0,260	0,260	40,158
2017	0,269	0,269	50,484
2018	0,277	0,277	68,364
2019	0,286	0,286	52,755
2020	0,291	0,291	40,918
2021	0,297	0,297	67,936
2022	0,308	0,308	62,169
2023	0,323	0,323	64,682
2024	0,331	0,331	44,167
Rata-rata	93,79	0,289	53,291

The estimation results show that the average fishing production cost is IDR 0.29 million per trip. Historically, operational costs show an increasing trend, with the lowest value in 2015 at IDR 0.25 million per trip and peaking in 2024 at IDR 0.33 million per trip. Meanwhile, the average price was recorded at IDR 53.28 million per ton, with the lowest price occurring in 2015 at IDR 40.16 million per ton and the highest price reached in 2018 at IDR 68.36 million per ton.

3.4 Bioeconomic Analysis

Based on the bioeconomic analysis using the CYP model, the estimated results of production parameters, fishing effort, and economic rent under four different management regimes (actual condition, Maximum Economic Yield (MEY), Open Access Equilibrium (OAE), and Maximum Sustainable Yield (MSY)) were obtained. The results of Bioeconomic analysis are presented in **Table 5** below.

Table 5. Bioeconomic Results under Various Blue Swimming Crab Resource Management Regimes.

Resource Utilization	Management Regime			
	Actual	MEY	Open Access	MSY
Biomass (x) (Ton)		20,59	10,25	15,46
Produksi (h) (Ton)	86,46	58,81	58,58	66,08
Effort (E) (trip)	12.283	5.396	10.792	8.073
π (juta Rp)	1.055	1.573	0	1.186

The bioeconomic analysis shows that the Maximum Economic Yield (MEY) regime is the most optimal management condition, with production of 58.8 tons and effort of 5,396 trips, which increases profits by 49% (IDR 1.573 billion) while maintaining the highest biomass compared to the actual condition. Although the Maximum Sustainable Yield (MSY) provides the highest production of 66.1 tons with 8,073 trips, its economic profit remains below MEY, while the Open Access Equilibrium (OAE) regime reflects extreme inefficiency with zero profit and the lowest biomass due to excessive effort.

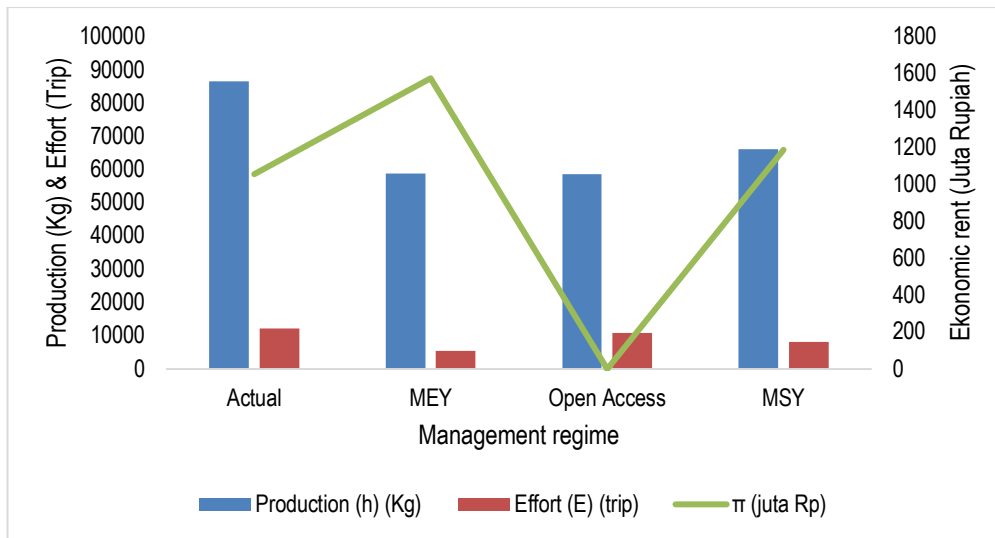


Figure 4. Economic Rent, CPUE, and Production Under Various Blue Swimming Crab Management Regimes.

3.5 Comparison of Actual Production with Sustainable Production

Currently, the blue swimming crab fishery at PPN Karangantu has experienced economic overfishing because the actual effort (12,283 trips) has exceeded the MEY and MSY limits. Therefore, policy intervention is needed to reduce fishing effort to the range of 5,000–6,000 trips per year to ensure economic optimization and stock sustainability. Throughout the 2015–2024 period, the comparison between actual production and sustainable production of blue swimming crab at PPN Karangantu shows a fluctuating pattern with an increasing frequency of overfishing in recent years. Of the ten years of observation, six years recorded actual production exceeding the sustainable limit (2016, 2018, 2019, 2021, 2022, and 2024), with the highest peak occurring in 2024 (115.57 tons), far above the sustainable production (94.89 tons). Although there were years when production fell below the sustainable limit (2015, 2017, 2020, and 2023), the dominance of overfishing in the second half of the period indicates increasingly intensive fishing pressure that risks disrupting the sustainability of blue swimming crab stocks, thus requiring stricter management policy interventions.

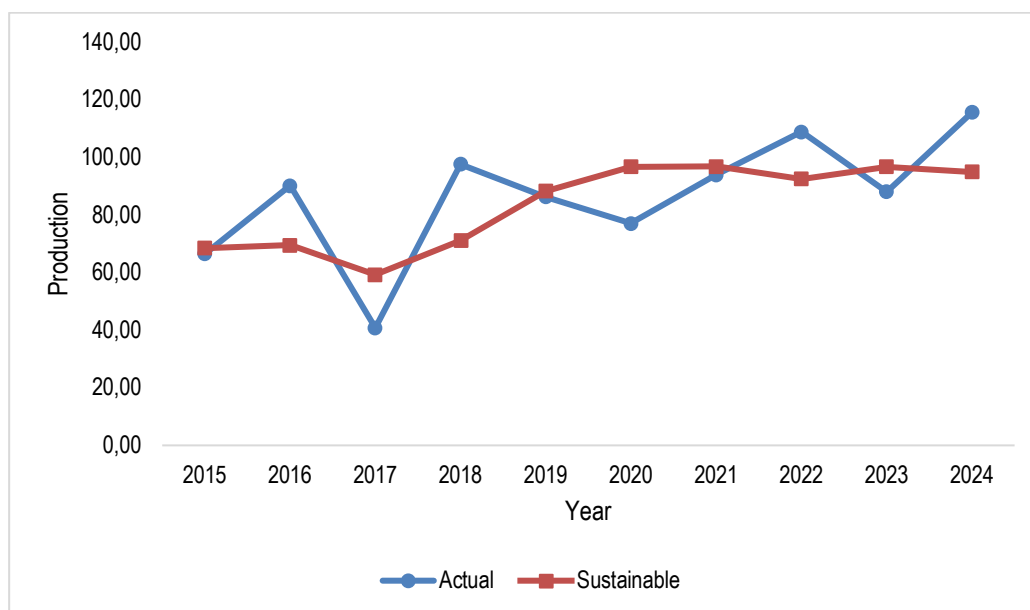


Figure 5. Comparison of Actual Production With Sustainable Production.

3.6 Policy Analysis and Simulation

Based on the bioeconomic analysis results indicating that the blue swimming crab fishery at PPN Karangantu has experienced high exploitation pressure with indications of economic overfishing (actual effort of 12,283 trips far exceeds the MEY optimum effort of 5,396 trips) as well as production fluctuations that often exceed the sustainable limit, management policies are necessary. Implementing a measured fishing scheme based on quota allocation per vessel, as mandated by Indonesian regulation No. 11/2023, is essential to reduce excessive effort and restore stock productivity. The approaches that can be applied include both input and output controls to control fishing intensity and restore the health of blue swimming crab stocks.

a. Input Control through Effort/Fishing Trip Limitation

The effort limitation simulation in **Table 5** provides a quantitative picture of effort allocation and reduction targets needed to achieve optimal MSY and MEY management conditions at PPN Karangantu. The standardization process using the fishing power index transformed the initial effort composition from 17,248 trips (Set Gill Nets 61%, Dogol 29%, and Pots/Traps 10%) to 12,283 standardized trips. This conversion result shows a significant change in proportions, where Set Gill Nets dominate at 85% (10,501 trips), while Bottom Trawls/Dogol and Pots/Traps each contribute only 7%. This adjustment confirms the dominance of Set Gill Nets as the main fishing unit and serves as crucial baseline data for formulating more accurate input control policies for blue swimming crab fisheries.

Table 5. Simulation of Fishing Effort Limitation Calculation.

Kriteria	Set Gill Nets (Trips)	Bottom Trawls / Dogol (Trips)	Bubu (Pots / Traps) (Trips)	Total
Average effort before standardization	10.501	5022	1725,2	17.248
Average effort after standardization	10.501	900	881	12.283
Share (Total Effort/Effort per gear type before standardization)	0,61	0,29	0,10	1,00
Share (Total Effort/Effort per gear type after standardization)	0,85	0,07	0,07	1,00
Effort Calculation Based on MEY and MSY Regimes				
MEY		5396		
MSY		8073		
Standardized Effort Quota (MEY)	4.613	395	387	5.396
Standardized Effort Quota (MSY)	6.902	592	579	8.073
Real Effort Quota (MEY)	4.613	2.521	781	7.916
Real Effort Quota (MSY)	6.902	3.772	1.168	11.842
Reduction Amount for MEY Regime	5.888	2.501	1.338	9.726
Reduction Amount for MSY Regime	3.599	1.250	557	5.406

The allocation of fishing effort quotas is based on the standard share proportion to achieve the MEY regime of 5,396 trips and the MSY regime of 8,073 trips. Under the MEY regime, the real quotas allocated are 4,613 trips for Set Gill Nets, 2,521 trips for Dogol, and 781 trips for Pots/Traps, while under the MSY regime they receive 6,902 trips, 3,772 trips, and 1,168 trips respectively. Compared to the average actual effort of 17,248 trips, achieving the MEY target requires a total reduction of 9,726 trips, consisting of a reduction of 5,888 trips for Set Gill Nets, 2,501 trips for Dogol, and 1,338 trips for Pots/Traps. Meanwhile,

achieving the MSY target requires a total reduction of 5,406 trips, with reductions of 3,599 trips for Set Gill Nets, 1,250 trips for Dogol, and 557 trips for Pots/Traps.

b. Fishery Output Control

Sustainable utilization of fishery resources in the waters of Serang, Banten, is based on the Maximum Sustainable Yield (MSY) concept by setting the Total Allowable Catch (TAC) at 80% of the total sustainable potential as a safety margin in accordance with the mandate of Minister of Marine Affairs and Fisheries Regulation No. 22 of 2021. Based on the Schaefer model analysis, the MSY value was set at 66.08 tons, resulting in a TAC of 52.86 tons to prevent overfishing and ensure population regeneration.

$$\text{TAC} = 80\% \times 66,08 \text{ Ton} = 52.86 \text{ tons}$$

The allocation of fishing quotas from the total TAC is distributed based on the Fishing Power Index, where Set Gill Nets receive the largest portion of 45.197 Ton (85%), while Bottom Trawls/Dogol and Pots/Traps receive quotas of 3.87 Tons and 3.79 Tons (7%) respectively. The implementation of this policy is crucial given that historical data shows dynamic fluctuations in production relative to fishing effort in the area.

c. Quotas

The quota system, or Individual Transferable Quotas (ITQs), is applied as a property-rights-based management mechanism to prevent stock degradation and optimize the market by dividing the total TAC of 52.86 Ton among various fishing gear units. Based on the fishing power index, Set Gill Nets dominate the quota allocation with 85% the equivalent of 45.19 Tons, while Bottom Trawls/Dogol and Pots/Traps each receive 7% with volumes of 3.87 Tons and 3.79 Tons. This proportional distribution aims to ensure fair access to utilization according to the efficiency of each fishing gear at PPN Karangantu, while also ensuring that pressure on fish biomass remains below the sustainable threshold.

Table 6. Calculation of Blue Swimming Crab Fishing Quotas.

Gears	Share (Based on Fishing power Indeks)	TAC/JTB (80% * MSY) (Unit = Tons)	Quota/gear (Unit =Tons)
Set Gill Nets	0,85	52.86	45.19
Jaring Hela Dasar / Dogol	0,07		3.87
Bubu (Pots / Traps)	0,07		3.79
Total	1,00		52.86

d. Policy Implications: Input Control, Output Control, and ITQs

The management strategy for blue swimming crab at PPN Karangantu must be carried out through the simultaneous integration of input and output controls, beginning with the reduction of real fishing effort toward the target of 5,000–6,000 trips/year to achieve the MEY condition. Technically, this requires a reduction of 5,888 trips for Set Gill Nets, 2,501 trips for Dogol, and 1,338 trips for Pots/Traps through permit moratoriums and fishing gear restrictions. In line with this, output control is applied through the allocation of TAC-based quotas of 52.86 Tons/year, where Set Gill Nets receive 45.19 Tons, while Dogol and Pots/Traps receive 3.87 ton and 3.79 ton respectively. In accordance with the Measured Fishing policy (Penangkapan Ikan Terukur/PIT) based on Government Regulation Number 11 of 2023, fisheries management has shifted from solely relying on input control to a combination of both. This approach not only sets limits on vessel capacity, gear type, and mesh size (input control), but more importantly, determines catch quotas (output control) based on the scientifically calculated Total Allowable Catch (TAC) to prevent overfishing. As a long-term instrument, the application of Individual Transferable Quotas (ITQs) can provide certainty of fishing rights and incentives for stock sustainability. However, this policy

must be differentiated; strict limitations are imposed on fishing gear that targets blue swimming crab as the main catch, while for fishing gear that catches blue swimming crab as bycatch, the focus is shifted to improving technological selectivity as well as regulating fishing areas and seasons to protect the WPP 712 ecosystem without harming fishers targeting other commodities.

4. Conclusion

The bioeconomic analysis of the blue swimming crab fishery at PPN Karangantu (2015–2024) concludes that the utilization status has exceeded the sustainable limit (overfishing), as indicated by the drastic decline in CPUE from 0.144 ton/trip to 0,058 ton/trip and actual production in 2024 (115.57 tons) exceeding the sustainable production threshold (94.89 tons). Biologically, blue swimming crab has a high growth rate ($r = 8.54$) but with limited environmental carrying capacity ($K = 30.94$ tons), making it highly vulnerable to fishing pressure. Optimal management through the MEY regime recommends an effort of 5,396 trips and production of 58.8 tons to achieve maximum profit of IDR 1.573 billion, or a 49% increase from actual profit through a 56% effort reduction. Therefore, an integrated policy is needed that includes input control toward the target of 5,000–6,000 trips/year, the implementation of output quotas (TAC) with strict monitoring, and long-term ITQs instruments that differentiate treatment between main target fishing gears (set gill nets and pots/traps) and bycatch gears (dogol). In line with the Measured Fishing policy (PP No. 11/2023), both input and output controls must be applied simultaneously. Input control limits effort, while output control allocates a scientifically determined TAC of 52,8 Ton/year. Strict quotas apply to main target gears, whereas bycatch gears prioritize technological selectivity and spatial-temporal closures.

Reference

- Anna, S. (2003). *Model embedded dinamik ekonomi interaksi perikanan-pencemaran* [Doctoral dissertation, Institut Pertanian Bogor].
- Clark, R. P., Yoshimoto, S. S., & Pooley, S. G. (1992). A bioeconomic analysis of the Northwestern Hawaiian Islands lobster fishery. *Marine Resource Economics*, 7(3), 115–140.
- Dahuri, R., Rais, J., Ginting, S. P., & Sitepu, M. J. (2008). *Pengelolaan sumber daya wilayah pesisir dan lautan secara terpadu*. Pradnya Paramita.
- Dewantara, E. C., Farhudin, A., & Wahyudin, Y. (2020). Bioeconomic analysis of *Stolephorus* sp. fisheries in the conservation area of Perairan Karang Jeruk, Tegal Regency, Central Java. *ECSoFiM: Journal of Economic and Social of Fisheries and Marine*, 8(1), 54–67.
- Fauzi, A., & Anna, S. (2005). *Pemodelan sumber daya perikanan dan kelautan*. Gramedia Pustaka Utama.
- Gordon, H. S. (1954). The economic theory of a common-property resource: The fishery. *Journal of Political Economy*, 62(2), 124–142.
- Ihsan, F. (2023). *Analisis bioekonomi perikanan rajungan (Portunus pelagicus) di Perairan Teluk Banten* [Bachelor's thesis, Universitas Pendidikan Indonesia].
- Kementerian Kelautan dan Perikanan. (2021). *Peraturan Menteri Kelautan dan Perikanan Nomor 22 Tahun 2021 tentang Penyusunan Rencana Pengelolaan Perikanan dan Lembaga Pengelola Perikanan Wilayah Pengelolaan Perikanan Negara Republik Indonesia* (Berita Negara Republik Indonesia Tahun 2021 Nomor 425).
- Kementerian Kelautan dan Perikanan. (2024). *Peraturan Menteri Kelautan dan Perikanan Republik Indonesia Nomor 7 Tahun 2024 tentang Pengelolaan Lobster (Panulirus spp.), Kepiting (Scylla spp.), dan Rajungan (Portunus spp.) di Wilayah Negara Republik Indonesia*.
- Muawanah, U., Huda, H. M., Koeshenderajana, S., Nugroho, D., Anna, Z., Mira, M., & Ghofar, A. (2018). Keberlanjutan perikanan rajungan Indonesia: Pendekatan model bioekonomi. *Jurnal Kebijakan Perikanan Indonesia*, 10(1), 1–12.

- Mursyid, M. F., Prabowo, P. A., Sudrajat, I. P., Puspa, D., Farhandika, N., Moumitay, A. Z. A., Suharti, R., Kadarusman, & Triyono, H. (2020). Aspek biologi rajungan (*Portunus pelagicus*) di Teluk Banten, Indonesia. *Buletin JSJ*, 2(2), 83–92.
- Pelabuhan Perikanan Nusantara Karangantu. (2019). *Laporan statistik perikanan tahunan Pelabuhan Perikanan Nusantara Karangantu 2019*.
- Pelabuhan Perikanan Nusantara Karangantu. (2024). *Laporan statistik perikanan tahunan Pelabuhan Perikanan Nusantara Karangantu 2024*.
- Pemerintah Republik Indonesia. (2023). *Peraturan Pemerintah Republik Indonesia Nomor 11 Tahun 2023 tentang Penangkapan Ikan Terukur* (Lembaran Negara RI Tahun 2023 Nomor 11). Sekretariat Negara.
- Schaefer, M. B. (1957). Some considerations of population dynamics and economics in relation to the management of marine fisheries. *Journal of the Fisheries Research Board of Canada*, 14(5), 669–681.
- Trenggono, S. W. (2024). *Menteri KP: Penangkapan ikan harus terukur, gunakan output kontrol* [Press release]. Radio Republik Indonesia. <https://rri.co.id>
- Wahyudin, Y. (2016). Potensi bisnis kelautan di negara maritim poros dunia untuk kesejahteraan rakyat Indonesia. *Agrimedia*, 21(1), 17–23.

