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CONDITIONS OF CAPTURE FISHERIES IN THE COASTAL AREA OF BATAM ISLAND KEPULAUAN RIAU PROVINCE

Kondisi Perikanan Tangkap Perairan Pulau Batam Provinsi Kepulauan Riau

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ABSTRACT

The coastal area of Batam Island have a fairly high potential for capture fisheries and contribute to the community's economy, especially in coastal areas. Capture fisheries businesses must pay attention to economic and ecological sustainability. The purpose of this study is to analyze the sustainability of the capture fisheries business on Batam Island based on bio-economic aspects in order to provide an overview of fisheries business management. The analysis was carried out descriptively through the Gordon-Schaefer model approach with the Gordon logistics growth function. The analysis was carried out on three management conditions, namely Maximum Sustainable Yield (MSY), Maximum Economic Yield (MEY), and Open Access Equilibrium (OAE). The results of the study show that the optimal utilization of capture fisheries in the coastal area of Batam Island is around 7,823 units of fishing vessels every year. The production of catch in the Maximum Sustainable Yield condition is around 36,982 tons, in the the Maximum Economic Yield condition is around 36,977 tons, while in the Open Access Equilibrium condition is only around 1,646 tons.

Keywords: Bio-economy, Gordon-Schaefer, capture fisheries, Batam Island

ABSTRAK

Perairan Pulau Batam memiliki potensi perikanan tangkap yang cukup tinggi dan memberikan kontribusi terhadap perekonomian masyarakat, khususnya di wilayah pesisir. Bisnis perikanan tangkap harus memperhatikan keberlanjutan secara ekonomi dan ekologi. Tujuan penelitian ini adalah menganalisis keberlanjutan bisnis perikanan tangkap di Pulau Batam berdasarkan aspek bio-ekonomi agar dapat memberikan gambaran mengenai pengelolaan bisnis perikanan. Analisis dilakukan secara deskriptif melalui pendekatan model Gordon-Schaefer dengan fungsi pertumbuhan logistik Gordon. Analisis dilakukan terhadap tiga kondisi pengelolaan, yaitu saat *Maximum Sustainable Yield* (MSY), *Maximum Economic Yield* (MEY), dan *Open Access Equilibrium* (OAE). Hasil penelitian memperlihatkan bahwa upaya pemanfaatan optimum

perikanan tangkap di perairan Pulau Batam sekitar 7.823 unit armada penangkapan setiap tahun. Produksi hasil tangkapan pada kondisi *Maximum Sustainable Yield* sekitar 36.982 ton, pada kondisi *Maximum Economic Yield* sekitar 36.977 ton, sedangkan pada kondisi *Open Access Equilibrium* hanya sekitar 1.646 ton.

Kata Kunci: Bio-ekonomi, Gordon-Schaefer, perikanan tangkap, Pulau Batam

INTRODUCTION

Increased fisheries production should consider environmental carrying capacity and sustainability of fish resource stocks so that negative impacts such as over-fishing do not occur. High efforts to capture fish resources in a body of water will result in over-exploitation (Arkham *et al*., 2021) which generally occurs in waters and coastal areas with small fishing gear (>5GT) (Limbong, 2020; Panggabean *et al*., 2023a; Panggabean *et al*., 2023b; Telussa *et al*., 2022). Management of fish resources by paying attention to the condition of fish resource stocks is a must so that the capture fisheries sector can continue to provide sustainable economic impacts in the future. One method that can be used for fish resource management concerning fish resource stocks is the catch approach which is able to describe the condition of fish resources (Nazzla *et al*., 2024; Panggabean & Nazzla, 2020; Panggabean & Nazzla, 2022). Estimation of the Maximum Sustainable Yield (MSY) value of fish resources in waters can be estimated using landed catch data, so that policies regarding the allowable catch value can be applied (Kristiana *et al*., 2021).

The MSY value is able to predict the level of utilization and sustainable fishing strategies. Estimation of MSY, catch productivity, level of utilization of fish resources, and level of fishing capacity can predict the condition of the status of fisheries resources in a water (Kristiana *et al*., 2021; Panggabean *et al*., 2023a; Panggabean *et al*., 2024; Taher *et al*., 2020). The condition of fish resources in the waters of Batam Island is very important to know so that the stock of fish resources can be managed properly so that the fisheries business can continue to provide long-term welfare, although fishing activities in the waters of Batam City are dominated by environmentally friendly fishing gear, recommendations for ecosystem-based strategies need to be carried out for the management of fish resources in the waters of Batam Island (Devina & Panggabean, 2024; Muzwardi *et al*., 2023; Siregar *et al*., 2020; Wijaya *et al*., 2021).

The bio-economic model approach is expected to contribute to developing management strategies for fishing efforts on Batam Island. So far, fisheries problems have focused more on efforts to maximize capture, and sometimes without considering production factors such as operational costs of capture. The purpose of this study is to analyze the condition of capture fisheries on Batam Island based on bio-economic aspects, so that they can be used as a reference for decision makers in formulating policies.

RESEARCH METHODS

The research was conducted on Batam Island and its surrounding waters in April-June 2024, data collection was carried out at the Berelang Fishing Port and Telaga Punggur (Figure 1).

Data and information collection in this study was carried out using field observation methods, literature studies and in-depth interviews with fishing boat captains, fishermen, and related agencies. Primary data consists of data on fishing productivity and fisheries economic aspects, while secondary data on fishing and economic aspects were also collected for nine years from the fisheries office and related agencies.

Catch per Unit Effort (CPUE) was determined using quantitative data on fishing productivity, fish utilization rates, and optimum fishing efforts in the waters of Batam Island.

$$CPUE = \frac{catch_i}{effort_i}$$

Information:

Catch : Catch of the year i. (tons)
Effort : The arrest attempt of the year i. (unit)
t : 2014 to 2022.

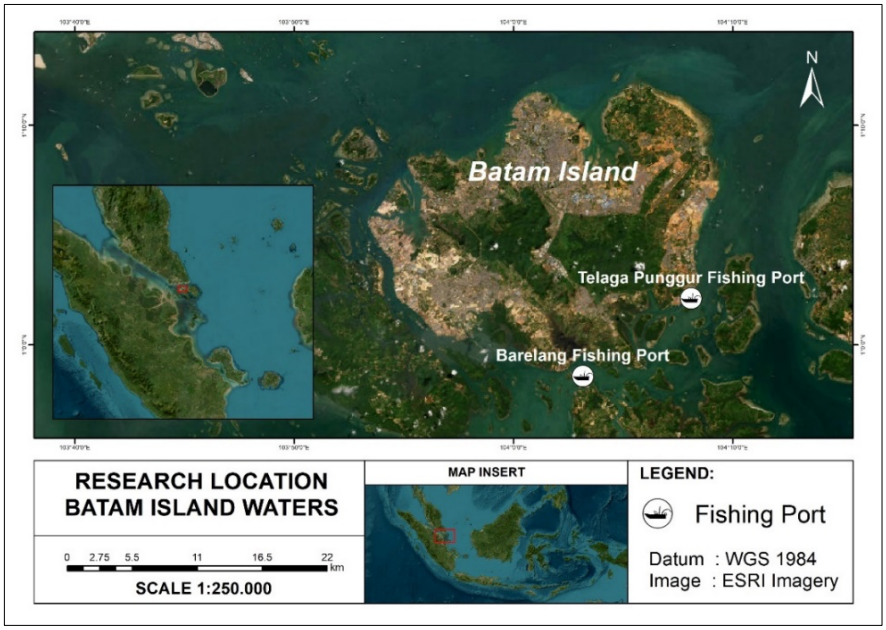

Figure 1. Location of Batam Island Waters and Fishing Ports

Utilization rate is the resources that have been utilized calculated per year..

$$Tp = \frac{C_i}{TAC} x100\%$$

Information:

Tp : Level of utilization of fish resources
C_i : Catch results of the i-th year
TAC : *Total Allowable Catch (80% of MSY value*)

Static bioeconomic analysis using the Gordon-Schaefer model approach with Gordon's logistic growth function. There are three equilibrium conditions in the Gordon-Schaefer model, namely, Maximum Sustainable Yield (MSY), Maximum Economic Yield (MEY), and Open Access Equilibrium (OAE). The bioeconomic analysis formula for various management regimes can be seen in Table 1.

Table 1. Bioeconomic Model Formula of Gordon-Schaefer

Variabel	**Kondisi**		
	MSY	**MEY**	**OAE**
Biomass (x)	$\frac{K}{2}$	$\frac{K}{2}\left(1+\frac{c}{pqK}\right)$	$\frac{c}{pq}$
Effort (E)	$\frac{r}{2q}$	$\frac{r}{2q}\left(1-\frac{c}{pqK}\right)$	$\frac{r}{q}\left(1-\frac{c}{pqK}\right)$

Catch (h)	$\frac{rK}{4}$	$\frac{rK}{4}\left(1+\frac{c}{pqK}\right)\left(1-\frac{c}{pqK}\right)$	$\left(\frac{rc}{pq}\right)\left(1-\frac{c}{pqK}\right)$
Rente (π)	$p.h_{MSY} - c.E_{MSY}$	$p.h_{MEY} - c.E_{MEY}$	$p.h_{OAE} - c.E_{OAE}$

Information:

K : environmental carrying capacity (tons per year);
q : coefficient of capture capacity (1 per unit effort);
r : percentage of fish biomass growth rate (% per year);
c : fishing costs (rupiah per attempt);
p : fish selling price (rupiah per ton).

RESULT

Fish catch production in the waters of Batam Island has continued to increase since 2014-2022 by around 34.51%, as explained in the graph in Figure 2.

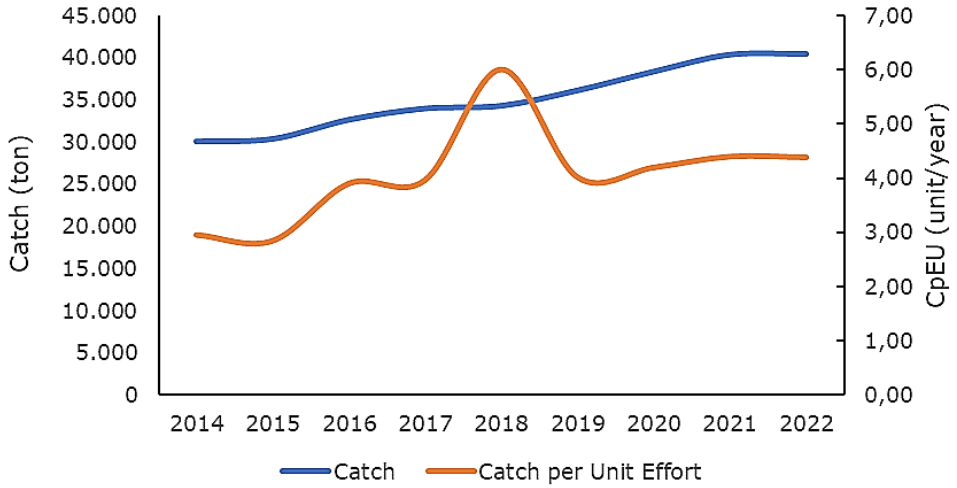

Figure 2. Graph of Capture Fisheries Productivity in Batam Island Waters 2014-2022

Fish catch production on Batam Island has continued to increase since 2014-2022 by around 34.51%. The catch in 2012 was around 26,193 tons, and in 2022 around 40,483.28 tons, while the production value increased by around 34.22%, where in 2014 around Rp.850.274 billion to Rp.1,374.427 billion in 2022. The catch production on Batam Island is more dominant from Galang, Bulang, and Belakang Padang Districts. This is because most of the fishing households on Batam Island are domiciled in these three districts. The productivity of capture fisheries in the waters of Batam Island has continued to increase since 2014-2022 (see Figure 2). The catch production from the sea in 2022 reached 40,483.28 tons with a productivity of around 4.39 units per year. The results of this study show that the level of fish utilization in the waters of Batam Island has exceeded the limit of around 119.02%, while the optimum utilization effort is around 7,823 fishing fleet units per year.

The results of the calculation of the bio-economic analysis of fish resources in the waters of Batam Island in the three management regimes (MSY, MEY, and OAE) can be seen in Table 2. The average catch production in 2014-2022 was around 35,214 tons per year, the catch production value was around Rp. 1,047,593,512,544, and the fishing effort was around 8,906 units.

Table 2. Bio-economic model formula Gordon-Schaefer

Variabel	Kondisi		
	MEY	MSY	OAE
Biomass (ton)	78.813	77.936	1.754
Effort (unit)	7.735	7.823	15.469
Catch (ton)	36.977	36.982	1.646
Rente Ekonomi (Rp.)	1.073.862.416.652	1.073.723.296.563	-

The graph in Figure 3 explains the condition of OAE, where fishermen do not receive economic rent at the time, because the income from the catch is the same as the cost of fishing.

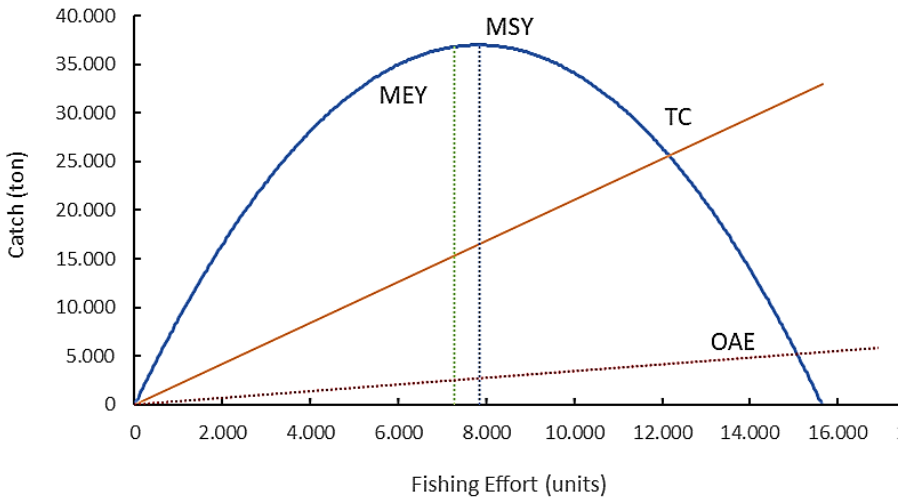

Figure 3. Total Cost for the Gordon-Schaefer Formula Bio-economic Model

The parameters used in the results of the bio-economic analysis of fish resources are resource biomass (x), catch (h), fishing effort (E), and economic rent (π). The results of the calculation of the bio-economic analysis of fish resources on Batam Island in the three management regimes can be seen in Table 2. The average catch production in 2014-2022 was around 35,214 tons per year, the catch production value was around Rp. 1,047,593,512,544, and the fishing effort was around 8,906 units. The highest amount of fish resource biomass occurred during MSY conditions, because the amount of biomass is inversely proportional to the amount of catch. The amount of fish resource biomass in MEY conditions was 78,813 tons, when the amount of catch was 36,977 tons per year. The higher the value of fish resource biomass will have a positive impact on the aquatic ecosystem. The maximum rent that can be obtained from the catch is Rp. 1,073,862,416,652 with an effort of 7,735 fleets) per year.

The biomass of fish resources at MSY conditions is 77,936 tons. The biomass of fish resources at MSY management regime is an ideal condition biologically for resource utilization by maximizing the amount of catch and the fishing effort allowed, but still paying attention to the availability of fish resources so that they remain sustainable. The economic rent generated at MSY conditions is IDR 1,073,723,296,563 with a catch of 36,982 tons and an effort level of 7,823 fishing units.

The highest fishing effort occurs at OAE conditions of around 15,469 units. The biomass of fish resources in the waters of Batam Island at OAE conditions is around 1,754 tons, while the catch is around 1,646 tons. The cost incurred by fishermen to utilize fishery resources in the waters of Batam Island is around IDR 3,160,500 per fishing effort, and the selling price of the catch reaches IDR 29,702,177 per ton.

DISCUSSION

The fisheries sector on Batam Island has experienced significant growth, because Batam City is a business center that also continues to grow, especially in processing high-quality food ingredients into snacks and ready-to-eat foods that can be sold to increase family income. This can be seen from the increasing number of coastal sub-districts that are being developed into fisheries production centers, especially capture fisheries. According to Wibowo *et al*., (2016) Galang, Kuala Kampar, Bulang, Belakang Padang, and Nongsa Districts have the potential for fisheries development on Batam Island. The fisheries center in Nongsa District always receives training in business plans, packaging, marketing, simple bookkeeping, and processing of marine products such as fish, seaweed, and gonggong (Asmirelda *et al*., 2020). In addition, routinely conduct product packaging training according to specified standards, as well as simple bookkeeping training for financial management.

The ever-increasing capture fisheries production makes the fisheries business on Batam Island increasingly attractive to many investors. The coastal population of Batam Island is highly dependent on marine resources, as seen from the majority of their income coming from capture fisheries (Noveria & Malamassam, 2015; Devina & Panggabean, 2024). Fishery production is positively related to investment in the fisheries sub-sector, the number of fishermen's houses, fisheries sector technology and last year's fisheries production, and has a significant effect on fisheries production (Malau & Hotman, 2018). The increase in capture fisheries production on Batam Island is dominated by purse seine fisheries to catch pelagic fish. The capture fisheries sector with a purse seine fishing fleet is one of the leading sectors to increase regional income (Rizieq *et al*., 2023). The MEY regime fisheries management is an optimal condition for fishing with more efficient use of efforts so that the economic rent obtained is at its maximum. MEY is an ideal condition for catching fishery resources both from an economic and biological perspective because it is economically efficient and the amount of catch produced does not exceed the maximum sustainable limit (Holma et al., 2019; Hoshino *et al*., 2018). Pattiasina *et al*., (2020) stated that increasing the biomass of fish resources has a positive impact on aquatic ecosystems, especially increasing the cover of live coral which is a habitat for various marine biota.

Actual catches that exceed or are less than the amount of catch and effort in the MEY regime will reduce the economic rent generated (Muawanah *et al*., 2018). Sheaves *et al*. (2017) stated that biomass is related to ecosystem productivity and directly affects fish species. The amount of effort and catch that exceeds MSY conditions can threaten the sustainability of fishery resources in the long term (Hilborn *et al*., 2015). The amount of effort made and the catch allowed in the MSY regime is greater than in MEY conditions, but the rent value generated in MSY conditions is smaller than the rent value in MEY conditions.

The open access fishery resource management regime occurs when there are no clear restrictions on fishery resource capture activities, either from the amount of input or the amount of output allowed. The resource management conditions in the OAE regime provide space for everyone to be able to catch, thereby increasing the extraction of fishery resources. Extraction of resources in open access conditions can result in over-fishing. Based on the graph in Figure 3, fishermen do not receive economic rent during OAE conditions, because the income from the catch is the same as the cost of fishing. This is because positive economic rent will encourage other fleets to participate in fishing activities until the economic rent is depleted. Open access conditions also cause degradation of fish resources in the waters as indicated by a significant decrease in biomass when compared to the MEY and MSY management regimes. The actual utilization of fish resources in the waters of Batam Island is approaching over-fishing economically and biologically. This is indicated by the number of actual fishing efforts that exceed fishing efforts during the MEY and MSY regimes. Fisheries management through output control regulations in the form of minimum legal size and prohibitions on fishing for

fish resources that are spawning is an appropriate step so that the availability of resources remains sustainable.

CONCLUSION

The condition of fish resource utilization in the waters of Batam Island is approaching over-fishing economically and biologically. The catch reached 40,483.28 tons, while the MSY value is only around 36,982 tons per year. The sustainability of capture fisheries in the waters of Batam Island can occur if a policy of reducing fishing efforts of around 1,083 fishing fleet units is implemented.

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