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Fisheries Management of Purse Seine Based on Bioeconomy Multispecies in the Sunda Strait

Widyanti Octoriani[1,*], Mennofatria Boer[2]

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ABSTRACT

The Sunda Strait is one of the areas with great fisheries potential. Most of the fishermen who fish in the Sunda Strait landed their catch at PPP Labuan, Pandeglang Regency. Purse seine is the gear with the largest production volume in Pandeglang Regency. Purse seine nets catch not only pelagic fish, but also demersal fish and bycatch. Therefore, it is important to analyze fisheries resource management policies using a multispecies approach. The purpose of this research is to determine the dependency relationships and the optimal exploitation rate for multispecies caught by purse seines using a multispecies bioeconomic model. The species studied in this research are Fringescale sardinella (*Sardinella fimbriata*), Indian Mackerel (*Rastrelliger faughni*), Mackerel tuna (*Euthynnus affinis*), Mackerel (*Scomberomorus* sp.), and Mackerel scad (*Decapterus russelli*). The results showed that the relationship between these species is competitive and that purse-seine fisheries management has not been operating optimally. The MEY (E_{MEY}) fishing effort needs to be regulated. The optimal exploitation rate is 236 trips/year. The quota for annual production is 452.87 tons/year for Fringescale sardinella (*Sardinella fimbriata*), 491.75 tons/year for Indian Mackerel (*Rastrelliger faughni*), 398.68 tons/year for Mackerel tuna (*Euthynnus affinis*), 370.68 tons/year for Mackerel (*Scomberomorus* sp.), and 282.25 tons/year for Mackerel scad (*Decapterus russelli*).

Keywords: Bioeconomy, fisheries management, multispecies, purse seine, Sunda Strait.

INTRODUCTION

The Sunda Strait is one of the Republic of Indonesia's fisheries management areas (WPP RI) 572. The Sunda Strait is one of the water areas with great fisheries potential, including both pelagic and demersal fish. The majority of fishermen who catch fish in the Sunda Strait land their catch in Pandeglang Regency. Pandeglang Regency is one of the regencies in Banten Province where most of the population works as fishermen (Octoriani *et al*., 2016). One of the sub-districts in Pandeglang Regency with a large fisheries potential and a majority of its population working as fishermen is Labuan Sub-district. Purse seine is the gear with the largest production volume in Pandeglang Regency. The potential of pelagic fish in Indonesian waters is 3.2 million tons/year, with a utilization rate of 46.59%; however, pelagic fish in Indonesia have mostly shown excessive levels of control, such as in the Java Sea and the Malacca Strait (Jalil *et al*., 2019). Fishing effort in WPP RI 572 is high enough to cause overfishing (Fuah *et al*., 2024).

The number of purse seine fleets in Pandeglang Regency continues to increase every year. Purse seine is a fishing gear used by fishermen to catch various types of pelagic fish. However, purse seines used by Pandeglang Regency fishermen also catch various types of demersal fish and some bycatch (Octoriani, 2015). Declining fish stocks and disruption of marine ecosystems can occur if fishing activities are not managed properly (Yusfiandayani *et al*., 2024). The objectives of fisheries management include biological, economic, and social objectives; namely, providing welfare to the community while maintaining the sustainability of the fish resources. Therefore, it is important to analyze fisheries

[1]*Corresponding author
✉ Widyanti Octoriani
widyantioctoriani@untidar.ac.id

[1]Program Studi Akuakultur, Fakultas Pertanian, Universitas Tidar, Indonesia.
[2]Departemen Manajemen Sumberdaya Perairan, Fakultas Perikanan dan Ilmu Kelautan, Institut Pertanian Bogor, Indonesia.

resource management policies using a multispecies approach based on purse-seine gear that considers ecological and economic factors. The purpose of this research is to determine the dependency relationship and optimal exploitation rate of multispecies caught by purse seines with a multispecies bioeconomic model. The multispecies optimal exploitation level is expected to provide insights for more optimal management of purse seine fisheries.

MATERIAL AND METHOD

Study period and location

This research was conducted from June to November 2016. The research was conducted at Labuan PPP, Pandeglang Regency, Banten Province (Figure 1).

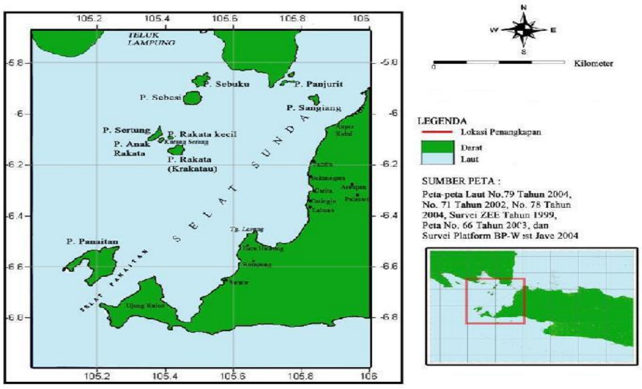

Figure 1. Research location at PPP Labuan, Pandeglang, Banten

Data collection

The data used in this research is secondary data sourced from the Pandeglang Regency Marine and Fisheries Agency. The statistical data include time-series data on catch (tons) and fishing effort (trips). The data used in this research span 2003 to 2015. The collected statistical data were analyzed using Microsoft Excel software.

Data analysis

The results of the data analysis are then presented descriptively through graphs or tables. The species studied in this research are the dominant catches of purse seines, including Fringescale sardinella (*Sardinella fimbriata*), Indian Mackerel (*Rastrelliger faughni*), Mackerel tuna (*Euthynnus affinis*), Mackerel (*Scomberomorus* sp.), and Mackerel scad (*Decapterus russelli*). Biological parameter estimation is done with the Schaefer surplus production model:

$$CPUE_t = qK + \frac{q^2K}{r} ft$$

While r is *the intrinsic growth*, q is the *catchability coefficient,* and K is *the carrying capacity*. And then, the multispecies bioeconomic model was analyzed as follows (Spare & Vanemma, 1999).

Table 1. Multispecies bioeconomic analysis formula at maximum economic yield (MEY), maximum sustainable yield (MSY) and open access (OA) regime

Variable	Management Regime		
	MEY	MSY	OA
Biomass (x)	$\frac{K_n}{2}\left(1+\frac{c_n}{K_n p_n q_n}\right)$	$\frac{K_n}{2}$	$\left(\frac{c_n}{p_n q_n}\right)$
Catch (h)	$q_n x_{nMEY} E_{nMEY}$	$\frac{r}{2q_n}$	$\frac{h_{nOA}}{q_n x_{nOA}}$
Effort (E)	$\frac{r_n}{2q_n}\left(1-\frac{c_n}{K_n p_n q_n}\right)$	$\frac{K_n r_n}{4}$	$\frac{r_n c_n}{p_n q_n}\left(1-\frac{c_n}{K_n p_n q_n}\right)$
Rente (π)	$p_n h_n - c_n E_n$	$p_n h_n - c_n E_n$	$p_n h_n - c_n E_n$

Management with a multispecies bioeconomic approach considers dependency relationships between species. There are several reciprocal relationships between species, namely competition, prey-predator, and independent relationships. The relationship between species in fishing activities can be written mathematically through the following equation:

$$\frac{dx_1}{dt} = F(x_1, x_2, x_3, x_4, x_5, x_6) = r_1 x_1\left(1-\frac{x_1}{K_1}\right) - a x_1 x_2 x_3 x_4 x_5 x_6$$

$$\frac{dx_2}{dt} = F(x_1, x_2, x_3, x_4, x_5, x_6) = r_2 x_2\left(1-\frac{x_1}{K_1}\right) - b x_1 x_2 x_3 x_4 x_5 x_6$$

$$\frac{dx_3}{dt} = F(x_1, x_2, x_3, x_4, x_5, x_6) = r_3 x_3\left(1-\frac{x_1}{K_1}\right) - c x_1 x_2 x_3 x_4 x_5 x_6$$

$$\frac{dx_4}{dt} = F(x_1, x_2, x_3, x_4, x_5, x_6) = r_4 x_4\left(1-\frac{x_1}{K_1}\right) - d x_1 x_2 x_3 x_4 x_5 x_6$$

$$\frac{dx_5}{dt} = F(x_1, x_2, x_3, x_4, x_5, x_6) = r_5 x_5\left(1-\frac{x_1}{K_1}\right) - e x_1 x_2 x_3 x_4 x_5 x_6$$

$$\frac{dx_6}{dt} = F(x_1, x_2, x_3, x_4, x_5, x_6) = r_6 x_6\left(1-\frac{x_1}{K_1}\right) - f x_1 x_2 x_3 x_4 x_5 x_6$$

While the n = 1^{st}, 2^{nd}, 3^{rd}, 4^{th}, 5^{th}, 6^{th} species, x_1 = biomass of Fringescale sardinella (tons), x_2 = biomass of Indian Mackerel (tons), x_3 = biomass of Mackerel tuna (tons), x_4 = biomass of Mackerel (tons), x_5 = biomass of Mackerel scad (tons), x_6 = biomass of other species (tons), r_n = natural growth rate of the species (tons/year), K_n = environmental carrying capacity of the species (tons/year).

After the values of a, b, c, d, e, and f are known, the type of relationship between species can be decided through Table 2 (Akhmad Fauzi, 2010).

Table 2. Relationship between species based on ecological dependence

Ecological dependence	Species 1	Species 2
Competition	$\partial x_1/\partial x_2 < 0$	$\partial x_2/\partial x_1 < 0$
Predator-prey (x_1 = predator and x_2 = prey)	$\partial x_1/\partial x_2 > 0$	$\partial x_2/\partial x_1 < 0$
Mutualism	$\partial x_1/\partial x_2 > 0$	$\partial x_2/\partial x_1 > 0$
Commensalism (x_1 = commensal)	$\partial x_1/\partial x_2 > 0$	$\partial x_2/\partial x_1 = 0$
Amensalism (x_1 = amensal)	$\partial x_1/\partial x_2 < 0$	$\partial x_2/\partial x_1 = 0$

The relationship between species is competitive if the values of a, b, c, d, e, and f are negative. The coefficient of dependence between species (x_1 and x_2) can be obtained by modifying the logistic model and using the Lotka-Volterra model (Akhmad Fauzi, 2010).

$$\frac{dx_1}{d_t} = r_1 x_1 \left(\frac{K_1 - x_{1.t} - \alpha_{12} x_{2.t}}{K_1}\right)$$

$$\frac{dx_2}{d_t} = r_2 x_2 \left(\frac{K_2 - x_{2.t} - \alpha_{21} x_{1.t}}{K_2}\right)$$

While α_{12} = the effect of species 2 on species 1, and α_{21} = the effect of species 1 on species 2.
The right-hand side of the above equation is the effect of the abundance of the competing species over time (x_2.t) expressed through $\alpha_{12}x_2$.t, where α_{12} is the competition dependence parameter for species 1.

When $\alpha_{12} < 1$, the effect of species 2 on species 1 is smaller than the effect of species 1 on its own members. And then when $\alpha_{12} > 1$, the effect of species 2 on species 1 is greater than the effect of species 1 on its own members. The optimal level of fishing effort considering the ecological dependency of fisheries can be obtained through the equation below (Akhmad Fauzi, 2010):

$$E_{1MEY} = \frac{\propto_{12}\propto_{21}c_1r_1r_2 - c_1r_1r_2 + K_1p_1q_1r_1r_2 - K_2\propto_{12}p_1q_1r_1r_2 + E_2K_2\propto_{12}p_1q_1q_2r_1 + E_2K_1\propto_{21}p_2q_1q_2r_2}{2K_1p_1q_1^2r_2}$$

$$E_{2MEY} = \frac{\propto_{12}\propto_{21}c_2r_1r_2 - c_2r_1r_2 + K_2p_2q_2r_1r_2 - K_1\propto_{21}p_2q_2r_1r_2 + E_1K_2\propto_{12}p_1q_1q_2r_1 + E_1K_1\propto_{21}p_2q_1q_2r_2}{2K_2p_2q_2^2r_1}$$

RESULT AND DISCUSSION

Result

Purse seine operating in the Sunda Strait and catches a variety of species, including Fringescale sardinella (*Sardinella fimbriata*), Indian Mackerel (*Rastrelliger faughni*), Mackerel tuna (*Euthynnus affinis*), Mackerel (*Scomberomorus* sp.), and Mackerel scad (*Decapterus russelli*). The fact that purse seines catch a variety of species requires a review of the proportion of each species' catch. The average proportion of purse seine catch during 2003 - 2015 is presented in Figure 2.

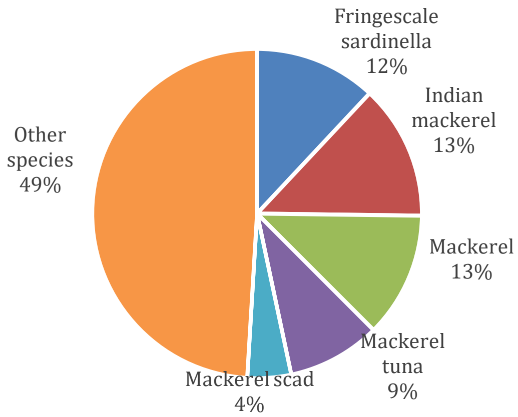

Figure 2. Catch composition of purse seine gear

Figure 2 shows that the largest proportion of purse seine catch is used to catch indian Mackerel (*Rastrelliger faughni*) and Mackerel (*Scomberomorus* sp.), each at 13%. This was followed by fringescale sardinella (12%), mackerel tuna (9%), mackerel scad (4%), and other species (49%). Other species are the sum of several species that are relatively small in number.

The biological parameters estimated were the environmental carrying capacity (K), the capture capacity coefficient (q), and the intrinsic growth rate (r). The biological parameters in this study were estimated through the Schaefer model. Information on the biological parameters of fish caught by the dominant purse seine is presented in Table 3.

Table 3. Biological parameters of five dominant species caught in Sunda Strait

Species	Biological parameters		
	K (tons/year)	q (tons/trip)	r (tons/year)
Sardinella fimbriata	75.6441	0.017899	24.1496
Rastrelliger faughni	4 262.2813	0.000175	0.4618
Scomberomorus sp.	252.438	0.006398	6.3189
Euthynnus affinis	2 990.7601	0.000275	0.4976
Decapterus russelli	990.3544	0.001036	1.1408
Other species	5 526.3258	0.000210	1.5449

The species targeted by purse seine are pelagic fish such as fringescale sardinella, Mackerel, indian Mackerel, mackerel tuna, and mackerel scad. The dependency relationships among multispecies fishery resources need to be understood so that management is not focused on a single species. Dependency coefficients between species are presented in Table 4.

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Table 4. Coefficient of interspecific dependence of fishery resources

Species	Coefficient of dependence
Fringescale sardinella (*Sardinella fimbriata*)	-11.7776E-15
Indian Mackerel (*Rastrelliger faughni*)	-8.1774E-15
Mackerel tuna (*Euthynnus affinis*)	-9.7269E-15
Mackerel (*Scomberomorus* sp.)	-7.7223E-15
Mackerel scad (*Decapterus russelli*)	-7.1763E-15
Other species	-55.7397E-15

The coefficient of dependence of all species is negative, which means that the relationship between these species is competitive. This may occur because the species have similar feeding habits. Other species are not further explained because they are a combination of various species. Small pelagic fish such as fringescale sardinella (*Sardinella fimbriata*) and Indian mackerel (*Rastrelliger faughni*) share a common food source: plankton (Jumrawati, 2019).

Estimation of economic parameters is required in bioeconomic studies. The required economic parameters that need to be estimated are cost and price factors. Fishing costs are obtained from interviews with respondents who are purse seine fishers. The economic parameters estimates are presented in Table 5.

Table 5. Economic parameters of five dominant species landed in the Sunda Strait.

Parameters	Species					
	S fimbriata	*R faughni*	*Scomberomorus* sp.	*E affinis*	*D russelli*	Other species
Cost (Rp/trip)	0.4855	0.3201	0.3950	0.4605	0.3244	2.3455
Price (Million Rp/tons)	4.17	15.9336	14.864	9.0782	11.779	10.183

Fringescale sardinella *(Sardinella fimbriata)* is the cheapest compared to other fish. This is because fringescale sardinella are not in high demand with the public and are only used as low-grade fish. Indian Mackerel (*Rastrelliger faughni*) is in demand as a food fish and is often in short supply, making it expensive. The obtained biological and economic parameters were used to determine the sustainable catch, optimum effort, and economic profit under MEY, MSY, open access, and actual management regimes. Results of the bioeconomic analysis are presented in Table 6.

Table 6. Utilization rate of fish resources

Species	Manag regime	X (tons)	H (tons)	E (trip)	π (Million Rp)
Sardinella fimbriata	MEY	41.28	452.87	612.97	1 606.10
	MSY	37.82	456.69	674.65	1 589.83
	OA	6.92	151.77	1 225.91	0.00
	Actual	26.94	413.67	857.84	1 312.54
Rastrelliger faughni	MEY	2 188.48	491.75	1 282.36	7 424.80
	MSY	2 131.14	492.11	1 317.82	7 419.12
	OA	114.69	51.53	2 564.73	0.00
	Actual	2 752.04	272.80	565.72	4 165.57
Scomberomorus sp.	MEY	128.30	398.68	485.73	5 734.26
	MSY	126.22	398.79	493.86	5 732.65
	OA	4.15	25.81	971.47	0.00
	Actual	75.38	336.56	697.94	4 727.09
Euthynnus affinis	MEY	1 587.46	370.68	847.77	2 974.69
	MSY	1 495.38	372.09	903.40	2 961.89
	OA	184.15	86.00	1 695.55	0.00
	Actual	1750.79	392.36	813.65	3 187.26
Decapterus russelli	MEY	508.47	282.25	535.74	3 150.89
	MSY	495.18	282.45	550.51	3 148.50
	OA	26.58	29.51	1 071.48	0.00
	Actual	465.41	276.40	573.18	3 069.88
Other species	MEY	3 310.47	2 050.76	2 944.02	13 978.64
	MSY	2 763.16	2 134.50	3 671.19	13 125.84
	OA	1 094.61	1 356.18	5 888.05	0.00
	Actual	2 291.73	1 998.65	4 144.67	10 631.80

Actual fishing effort for *Sardinella fimbriata*, *Scomberomorus* sp, *Decapterus russelli*, and other species has exceeded the fishing effort at MSY and MEY conditions. The actual fishing effort for *Rastrelliger faughni* and *Euthynnus affinis* remains below the levels at MSY and MEY conditions. The actual catch of *Euthynnus affinis* has exceeded the catch at MSY and MEY conditions. Then the catch of *Sardinella fimbriata*, *Scomberomorus* sp., *Decapterus russelli*, and other species is below the MSY and MEY catches. All fish resources will yield zero profit under open-access conditions.

The dependency coefficients, biological parameters, and economic parameters obtained were then used to estimate the optimum effort (E_{MEY}) of each species. The difference between the previous bioeconomic model and the competition bioeconomic model is that the latter considers the dependency coefficient between species. The implementation of the competition bioeconomic model for the dominant species caught by purse seines is presented in Table 7.

Table 7. The comparison of optimal effort based on the bioeconomy of competition

Competition	Species	Dependency coefficient	E_{MEY} (trip)
Sardinella fimbriata and *Rastrelliger faughni*	*Sardinella fimbriata* (species 1)	0.0123	504.8097
	Rastrelliger faughni (species 2)	25.2559	1 284.9430
Scomberomorus sp. and *Euthynnus affinis*	*Scomberomorus* sp. (species 3)	0.0731	236.7701
	Euthynnus affinis (species 4)	8.7261	1500.0172
Rastrelliger faughni and *Decapterus russelli*	*Rastrelliger faughni* (species 2)	1.4621	1076.3387
	Decapterus russelli (species 5)	0.1207	396.4579
Euthynnus affinis and *Decapterus russelli*	*Euthynnus affinis* (species 4)	1.4133	841.6807
	Decapterus russelli (species 5)	0.1897	381.8630

The dependence coefficients, biological parameters, and economic parameters obtained are then used to estimate the optimal effort (E_{MEY}) for each species. The difference between the previous bioeconomic model and the competition bioeconomic model is that the latter considers the dependency coefficient between species. The optimal fishing effort of mackerel species is higher than that of other species because Mackerel is the dominant species caught by purse seines. According to statistical data, mackerel are always caught with purse seines each year, unlike other species. The optimal effort (EMEY) from the competition bioeconomic analysis is lower than the E_{MEY} without accounting for species interactions.

Discussion

Because the species caught by purse seines compete, a bioeconomic analysis of competition was conducted. The bioeconomic model of competition was calculated for four competition conditions: *Sardinella fimbriata* vs. *Rastrelliger faughni*, *Scomberomorus* sp. vs. *Euthynnus affinis*, *Rastrelliger faughni* vs. *Decapterus russelli*, *and Euthynnus affinis vs. Decapterus russelli*. This selection is based on the same type of food. The main food of *Sardinella fimbriata* is various types of phytoplankton, such as Bacillariophyceae, Crustacea, Ciliata, and Dinophyceae, while additional food consists of invertebrates (Kartini, 2023). The main food of *Sardinella fimbriata* is the Bacillariophyceae and the crustacean group of copepod species (Asriyana *et al*., 2004). The main food of *Rastrelliger faughni* is phytoplankton, specifically Bacillariophyceae, while their additional food sources are finfish and zooplankton (Salsabila & Affandi, 2019). The food of *Rastrelliger faughni* is zooplankton. *Scomberomorus* sp. are carnivores, so their main food is small fish such as sardines and anchovies, squid, and crustaceans; while their additional food is zooplankton (Patiung *et al*., 2023).

Just like *Scomberomorus* sp., *Euthynnus affinis* is also a type of carnivorous fish. Hence, the main food of *Euthynnus affinis* is small fish and squid, while its additional food is molluscs, cephalopods, and finfish (Saraswati *et al*., 2020). *Euthynnus affinis* prey on small fish such as clupeoids, squid, crustaceans, and zooplankton (Patiung *et al*., 2023). The main food of *Decapterus russelli* is smaller invertebrates and planktonics, while the supplementary food is finfish and mollusks (Patiung *et al*., 2023).

The intrinsic growth rate (r) of *Sardinella fimbriata* is higher than that of other species. This indicates that the growth rate of *Sardinella fimbriata* is faster than that of other species, so the possibility of being caught quickly is higher. If pelagic fish resources living in a body of water have the same average natural growth rate (r), then the model cannot be used to predict the extinction of each species in these waters. The five species in this study have different R values. If r is greater, it can be predicted that the species is endangered or that its rate of rarity will be faster. The extinction rate of fish species with higher r values will be higher because they are larger and caught faster. The fishing power coefficient indicates the level of technical efficiency in fishing. Tembang fish has the highest catchability coefficient (q) among other species. The carrying capacity of the aquatic environment (K) for *Rastrelliger faughni* is greater than that of other species; this means that *Rastrelliger faughni* can live longer in the Sunda Strait than other species.

This study analyzes the utilization of fisheries resources under three conditions: *Maximum Sustainable Yield* (MSY), *Maximum Economic Yield* (MEY), and *Open Access* (OA). *Maximum Sustainable Yield* (MSY) is the maximum sustainable rate of utilization of fish resources. *Maximum Economic Yield* (MEY) is the maximum production that is economically efficient because it uses production factors (labor and capital) more efficiently, and is the optimal level of effort socially because it is lower, which is more friendly to the environment. Effort at MEY is the level of fishing effort that is sustainable and provides the largest difference between total revenue and total fishing costs. In other words, MEY is the maximum utilization level that provides maximum economic rents while maintaining the sustainability of fish resources. *The maximum Economic Yield* (MEY) regime of fisheries management is more optimal, but the production is below MSY. *Open access* is a description of fisheries activities such that no one is responsible (users) in maintaining the sustainability of resources because fishermen are free to catch anywhere.

The previously obtained biological parameters can be used to analyze sustainable fishing effort (E_{MSY}) and sustainable catch (h_{MSY}). The E_{MSY} value represents the number of purse seine trips required to achieve the maximum sustainable yield in the Sunda Strait. The h_{MSY} value indicates the maximum sustainable yield, i.e., the catch per species that can be taken without threatening the sustainability of the fishery resources. The actual effort of *Sardinella fimbriata*, *Scomberomorus* sp., *Decapterus russelli*, and other species has exceeded the optimum effort, resulting in a decrease in catch. The actual effort for *Rastrelliger faughni* has not reached the optimum effort, so the catch is below the sustainable catch (h_{MSY} and h_{MEY}). Then the actual effort for *Euthynnus affinis* has not reached the optimum effort, but the catch has exceeded it. Year-to-year fluctuations in production occur due to changes in fishing effort. When fishing effort increases, more fish will be caught, and catches may even exceed sustainable production. If the actual catch exceeds the sustainable level, it indicates that species extinction can occur soon, or even that overfishing can occur. This is what happened to *Euthynnus affinis*, the actual has exceeded h_{MSY} and h_{MEY}. The actual effort (E_{actual}) of *Sardinella fimbriata*, *Scomberomorus* sp., *Decapterus russelli*, and other species has exceeded E_{MEY} and E_{MSY}, meaning that there has been massive exploitation of these species. Then the E_{actual} of *Rastrelliger faughni* is still below E_{MEY}, indicating that its utilization is still low. This situation indicates that *Sardinella fimbriata*, *Scomberomorus* sp., *Decapterus russelli*, *Euthynnus affinis*, and other species are subject to biological overfishing.

Economic overfishing is a situation in which fisheries should be able to produce positive economic rents, but, in fact, produce zero economic rents due to excessive input (effort) utilization. Economic overfishing can occur in two ways. First, in unregulated fisheries, fishermen catch small fish, thereby eliminating future economic benefits. Second, an increase in the amount of fishing effort that is not regulated. Based on the results of bioeconomic analysis, the actual effort of *Sardinella fimbriata*, *Scomberomorus* sp., *Decapterus russelli*, and other species has exceeded the optimal effort so that the actual benefits received are also smaller than in MSY and MEY conditions. This condition indicates that these species are subject to biological overfishing and economic overfishing. Then the economic rent of *Euthynnus affinis* in actual conditions is greater than the optimal profit both in MSY and MEY. A large difference in production and profits between actual conditions and MSY and MEY conditions indicates that *Euthynnus affinis* is experiencing biological overfishing and economic overfishing (Sulistianto, 2022).

The implementation of the competition bioeconomic model shows that the optimal fishing effort of *Rastrelliger faughni* is higher than that of other species, because *Rastrelliger faughni* is the dominant species caught by purse seines. In addition, according to the Pandeglang Regency Marine and Fisheries Agency (2015), *Rastrelliger faughni* are consistently caught with purse seines each year, unlike other species.

The overall results show that purse seine fisheries management has not been running optimally. The impact is the lack of catch and the economic benefits that fishermen obtain. Therefore, a management strategy must be developed to address the problems in purse seine fisheries management. The regulation of purse seine fishing effort is guided by the MEY (E_{MEY}) of bioeconomic competition to avoid overestimation and economic overfishing. MEY-based fisheries management can be implemented through input and output restrictions, depending on the community's social and economic conditions (Efendi *et al*., 2023). Limiting inputs means limiting the number of trips, while limiting outputs means limiting the volume of catch. Increasing the effort is no longer possible because it has exceeded the optimal limit. Management of purse seine fisheries can be achieved by reducing fishing effort to MEY conditions, enabling the sustainable use of fishery resources (Sulistianto, 2022). This policy must be fully supported by all parties to maintain the sustainability of fisheries resources and ensure that the economic benefits obtained are also sustainable (Sari & Nurainun, 2022) and social economy welfare (Wafi *et al*, 2019).

CONCLUSION

The dependency relationship between species caught by purse seines is competition. The optimal exploitation rate is 236 trips/year. This is based on the minimum number of trips from the multispecies competition bioeconomic results. Limiting fishing effort will reduce resource exploitation and thus prevent biological and economic overfishing. The quota for annual production is 452.87 tons/year for Fringescale sardinella (*Sardinella fimbriata*), 491.75 tons/year for Indian Mackerel (*Rastrelliger faughni*), 398.68 tons/year for Mackerel tuna (*Euthynnus affinis*), 370.68 tons/year for Mackerel (*Scomberomorus* sp.), and 282.25 tons/year for Mackerel scad (*Decapterus russelli*).

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