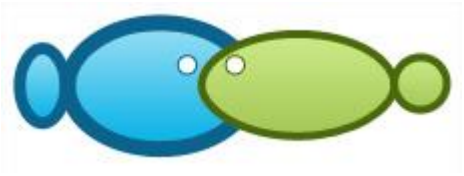

The potential of pelagic fish resources in the waters of Sulamu District, Kupang Regency, Indonesia

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Abstract. Management of fishery resources, especially pelagic fish resources, is not intended only to increase welfare, but also to maintain ecological balance and fulfill production continuously. To support sustainable management, utilization of fish resources must be carried out taking into account the estimated potential of pelagic fish resources. The level of utilization of fishery resources should be based on the maximum level of utilization that can be carried out in the Sulamu waters, Kupang Regency, East Nusa Tenggara Province. The aim of this research was to determine the potential of pelagic fish in the waters of Sulamu, East Nusa Tenggara. This research was carried out from June to August 2023 in the Sulamu District, Kupang Regency. Data analysis uses the surplus production method to calculate maximum sustainable yield and optimum fishing effort (f_{opt}) by analyzing the relationship between fishing effort and catch per unit effort. Catches from purse seine fishing gear were dominated by the species *Euthynnus affinis* (36.19%) and by the species *Katsuwonus pelamis* (31.21%), while those from the trolling gear contributed with 27.98%. In the studied area, the maximum sustainable yield is 1,080,172 kg year^{-1} and the optimal amount of effort that can be made is 7,000 trips year^{-1}. Currently the data shows that the fishing effort carried out has passed the Maximum Sustainable Yield threshold, causing catches to decrease every year.

Key Words: CPUE, maximum sustainable yield, pelagic fish.

Introduction. Sulamu District, Kupang Regency is a strategic area, namely a strategic area for economic and environmental functions. Sulamu has also been designated Special Economic Zone (SEZ), Minapolitan area and part of the Kupang Bay Marine Natural Tourism Park. Based on a report from the Ministry of Marine Affairs and Fisheries (2019), the contribution of tuna fish catch to the total income of fishermen in Sulamu District reached 37.35% of the total catch of 174 tons for all types of fish in 2019. Furthermore, a report from the Kupang Regency Central Statistics Agency (2021) showed that the total fish production has increased to 1020.33 tons, which is dominated by skipjack, tuna, mackerel, anchovy, and round scads fish in the Sulamu District area. The increase in fishing production in the Sulamu district during the 2019-2021 period is estimated to be due to an increase in the fleet and frequency of fishing conducted.

Currently, for fisheries in the Sulamu waters, Kupang Regency, East Nusa Tenggara Province, there is still not enough research on the potential of pelagic fish. Besides, recent data is still not considered in determining policies and fisheries resource management for large pelagic fish and small pelagic fish. Management of fishery resources, especially pelagic fish resources, is not only intended to increase welfare but also to maintain ecological balance and continuous production. The exploration in the Sulamu waters, Kupang Regency, East Nusa Tenggara Province must consider the potential of pelagic fish resources, in order to adjust the level of exploitation based on the maximum level of utilization. Therefore, in order to answer the challenges of managing pelagic fish resources in Sulamu District the potential of pelagic fish resources

was estimated by using the Schaeffer linear model, which is one of the approaches to the surplus production method (Aprilla et al 2023). The surplus yield method is used to estimate the potential of pelagic fish resources through analyzing the relationship between fishing effort (f) and catch (C) per unit effort (CPUE). Maximum sustainable yield is a balance between the fishing effort carried out and the recruitment rate of a type of the targeted fish (Finley & Oreskes 2013). The aim of this research was to determine the potential of pelagic fish in the waters of Sulamu, East Nusa Tenggara.

Material and Method

Study area. This research was carried out from June to August 2023 in the Sulamu District, Kupang Regency (Figure 1).

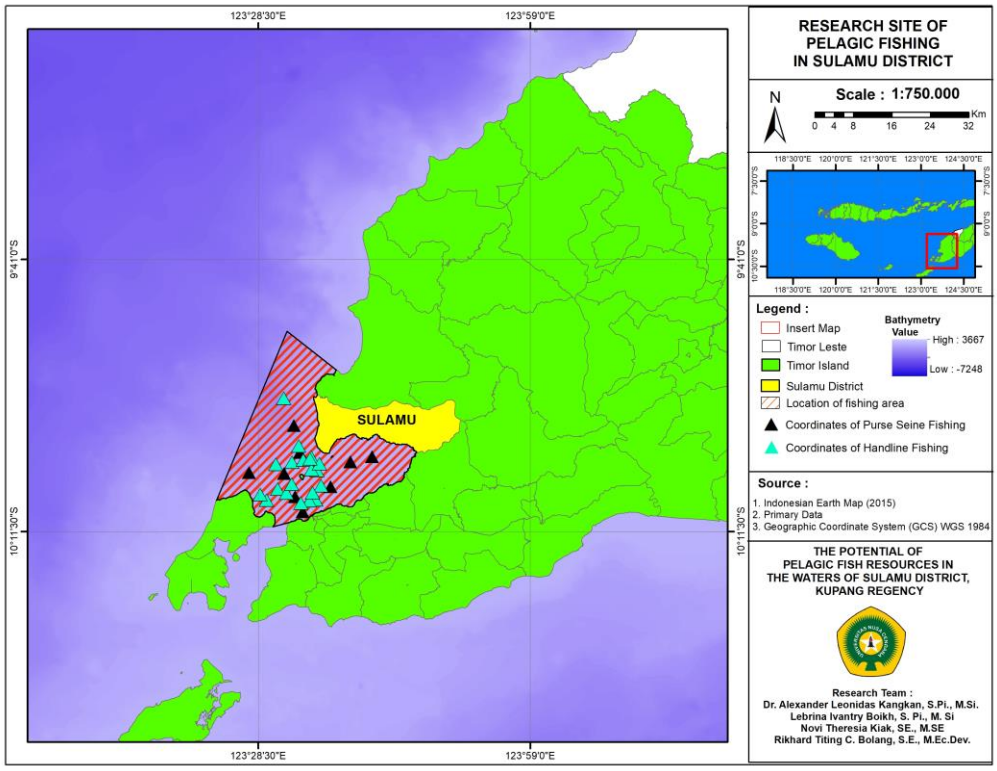

Figure 1. Map of the study area.

Procedures. The data collected in this research consisted of 2 types of data. Primary data consists of data on fishing catches and fishing locations, while the secondary data collected concern the fishing fleets and pelagic fish catches in 2011-2022 in the Sulamu District area.

Data processing and analysis. Data analysis uses the surplus production method to calculate the Maximum Sustainable Yield (MSY) and the optimum fishing effort (f_{opt}), by analyzing the relationship between fishing effort and catch per unit effort (CPUE). The analysis was carried out using the Schaeffer model approach, which is a regression analysis model of the CPUE variation with the amount of effort (Barr 2016; Fauziyah 2020; Aprilla et al 2023). The equation to calculate the CPUE value is, as follows:

$$CPUE = \frac{Ct}{ft}$$

Where:
CPUE - catch per unit effort;
Ct - catch in year t (ton);
ft - effort in year t (trip)

The relationship between C (catch) and f (fishing effort) is:

$$C= af+b(f)^2$$

The Optimum Effort Value (f_{opt}) is:

$$f_{opt} = - (a/2b)$$

The Maximum Sustainable Yield (MSY) value is:

$$MSY = -a^2/4b$$

Results and Discussion

Catch characteristics. The pelagic fishing carried out by the people of Sulamu District is carried out with fishing vessels ranging from 0-12 GT. The results of interviews with fishermen revealed that the fishing gear used to catch pelagic fish consists of 3 types: mini purse seine, fishing troll on and bagan. Based on the secondary data obtained, the trolling rods represents 61.4% of the fishing gear used in the Sulamu District (Figure 2).

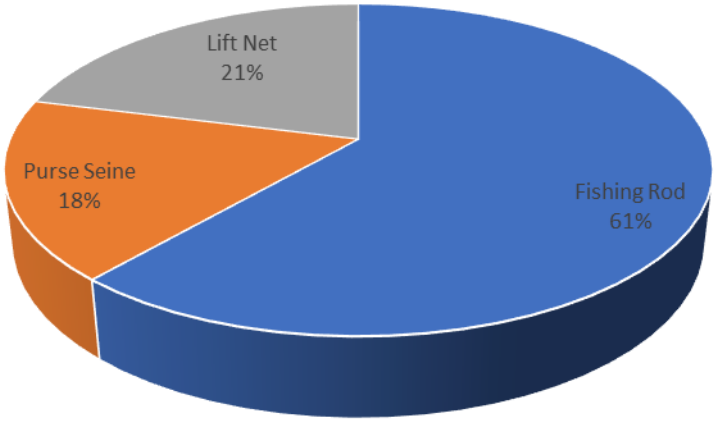

Figure 2. Types of pelagic fishing gear.

The characteristics of the fishing carried out on each type of fishing gear are different, Pelagic fishing using Trolling Rods is carried out twice a day, namely from 05.00-11.00 WIT and 13.00-18.00 WIT. The fishing operations of purse seine and chartreuse are carried out in a one day trip; the ship departs from the fishing base towards the fishing ground at 17.30 WITA and returns to the fishing base at 08.00 WITA. In general, the fishing area for Sulamu fishermen is in Kupang Bay, namely around Kupang Waters, Semau, Kera Island, Sulamu to Tanjung Toda. There were identified 20 fishing areas for purse seine vessels and 9 fishing areas for trolling rods. Purse seine vessels are mostly used in previously visited fishing areas, while trolling boats usually target schools of fish or FAD areas around the Sulamu waters.

The interviews showed that the fishing season occurred during June-December. In January-May, fishing is usually not carried out due to the western season in the waters of Kupang Bay. The peak season occurs in June-August when it is known that the catch can reach 3 tons landed in Sulamu District. Meanwhile, in September-December the catch landed in the Sulamu area is around 1-1.5 tons. Rahmah et al (2021) estimates that bad weather conditions will make it difficult for fishermen to catch yellowfin tuna, so that the fishing production will decrease. The observations revealed that the dominant catch component were the species *Euthynnus affinis* (Mackerel tuna), with a percentage of 36.19%, and the species *Katsuwonus pelamis* (Skipjack tuna), at 31.21%. Meanwhile, for the trolling equipment, the dominant catch components were *K. pelamis* species, with a percentage of 31.29%, and the *E. affinis* species, with a percentage of 27.98% (Table 1).

Table 1

Composition of catches from trolling and purse seine fishing

No	Species	Percentage (%)	
		Handline	Purse Seine
1.	*Mene maculata*	-	0.27
2.	*Tylosurus crocodilus*	2.32	1.78
3.	*Euthynnus affinis*	27.98	36.19
4.	*Katsuwonus pelamis*	31.29	31.21
5.	*Istiompax indica*	25.33	-
6.	*Charanx* sp.	8.11	-
7.	*Trichiurus lepturus*	4.97	-
8.	*Hemiramphus* sp.	-	9.41
9.	*Sardinella fimbriata*	-	6.87
10.	*Rastrelliger* sp.	-	5.74
11.	*Hirundichthys oxycephalus*	-	2.69
12.	*Decapterus* sp.	-	5.83

In the research conducted by Bere et al (2021) regarding the composition of mini purse seine catches in the waters of Kupang Bay, the tuna types dominate 88%. Purse seine fishing gear is also used to catch small pelagic fish such as sardines (El-Haweet 2001). Tuapetel et al (2022) stated that the types of fish that were targeted by the trolling fleet were large pelagic fish, namely tuna and skipjack; the types caught during the research belong to 4 families, namely Scombridae, Coryphaenidae. Carangidae and Istiophoridae. The distribution of skipjack tuna is also influenced by the spread or circulation of currents, especially where currents meet, which are areas with a high biodiversity, appropriate to be used as fishing grounds for skipjack tuna fisheries. Erfin (2018) stated that the environmental factors also influence the distribution of skipjack tuna, including oceanographic parameters such as temperature, salinity, depth, currents, and chlorophyll-A content, as a measure of the primary productivity. The density of phytoplankton in a body of water can influence the pelagic fish populations density, especially tuna (Mardatillah et al 2019).

The existence of differences in fish distribution patterns has an impact of different fishing areas as well as the number and type of fish caught (Figure 3), also influencing the use of different fishing gear for the type of fish that is the target of fishing on fish resources, in a multispecies aquatic environment (Mirnawati et al 2019).

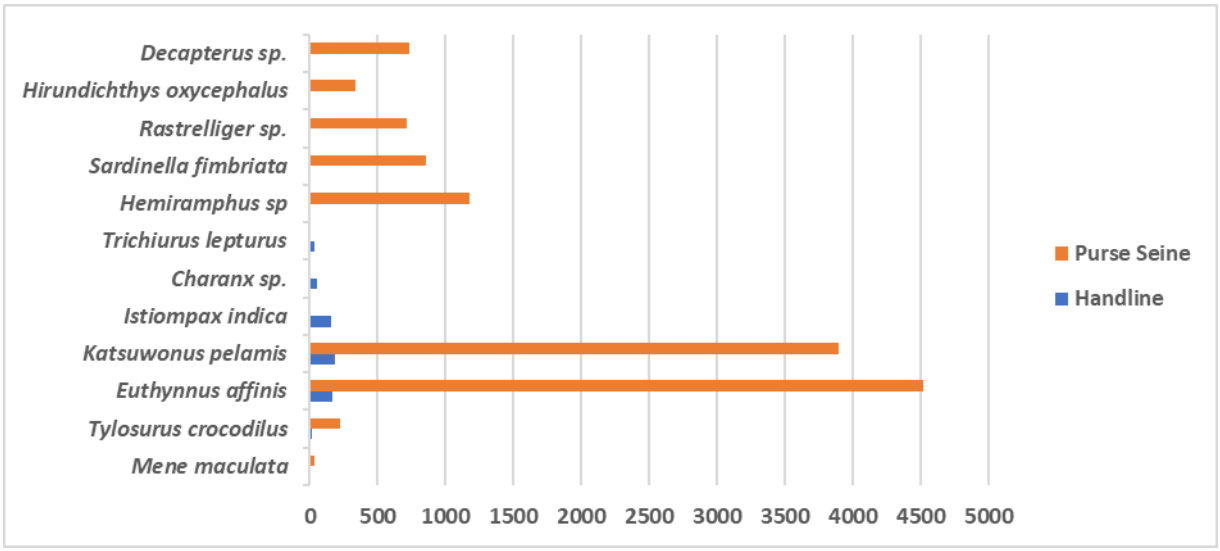

Figure 3. Quantities of pelagic fish catches.

Differences in the number of pelagic fish species in an environment can be influenced by the catch season, the migration of fish species in search of food, and their habitat capacity to sustaining life and growth.

Sustainable potential of pelagic fish resources in Sulamu District. Based on the secondary data from the Kupang Regency in figures (2012-2023), the condition of pelagic fishing in Sulamu District tends to decline. Devasa et al (2023) explained that the CPUE value is used as an indicator of the capture efficiency, based on a comparison of the catch abundance with the fishing effort. Based on data from Table 2, the effort is known to have increased during the 2011-2022 period. Due to a high level of exploitation, an increase in effort does not generate a proportional catch abundance. The highest CPUE value occurred in 2011, 241.76 kg trip^{-1}, while the lowest CPUE value was recorded in 2022, 89.42 kg trip^{-1}.

Table 2

Total production, fishing effort, and CPUE

Year	*Effort (trip)*	*Catch (kg)*	*CPUE (kg trip^{-1})*
2011	6,728	1,626,550	241.76
2012	6,728	1,393,770	207.16
2013	6,733	970,220	144.10
2015	6,734	989,060	146.88
2016	6,735	912,820	135.53
2017	6,972	896,390	128.57
2018	6,972	962,950	138.12
2020	7,692	902,710	117.36
2021	8,412	806,200	95.84
2022	10,812	966,790	89.42

The decline in pelagic fish resource stocks can be caused by the rate of increase in utilization, which tends to be greater than the recruitment capacity of pelagic fish resource stocks. Yahyah (2020) further stated that the factors causing variations in the CPUE values for the types of fish captured in the waters of multi-species tropical regions, such as the Kupang Bay, could be the abundance of fish resource stocks, the intensive fishing exceeding the resource stock recruitment ability and the fish characteristics.

The overexploitation is suggested when an increase in the fishing efforts will cause the productivity of fishing gear to decrease (negative correlation), resulting in a decrease in the CPUE value (Figure 4).

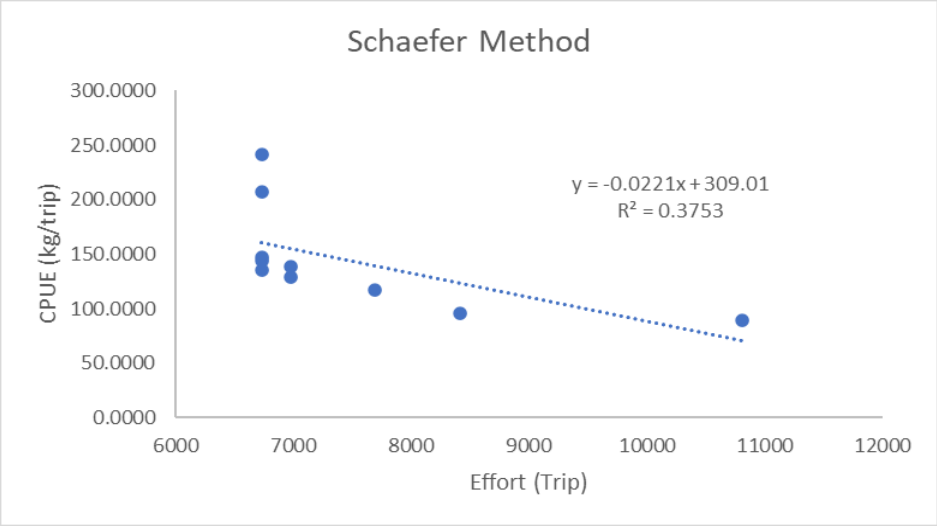

Figure 4. Relationship between CPUE and pelagic fish effort in Sulamu District.

The correlation equation (Figure 3) shows the parameters for the small pelagic fish surplus production model, namely a coefficient b of -0.0221 and a (intercept) of 309.01, with a coefficient of determination (R^2) of 0.7823. Consequently, every additional effort of 1 unit will reduce the CPUE by 0.0221 kg units. Aprilla et al (2023) explained that if the slope (b) value is negative, then each additional fishing effort will cause a decrease in the CPUE value by the value b and vice versa if the slope (b) value is positive (an additional fishing effort generates an increase in catches). When the relationship between CPUE and fish resource effort produces a decreasing trendline, there is an excess of fishing effort (trips).

The MSY analysis is one of the biological standards used in the management and conservation of sustainable fishery resources using the Schaefer method of production surplus (Barr 2016; Agus et al 2021; Rahmah et al 2021; Aprilla et al 2023). The MSY resulted from the research calculations is 1,080,172 kg year^{-1}, in the Sulamu District area. The MSY value shows the highest quantity of pelagic fish that can be caught in the Sulamu District area, which was, as shown in Figure 5.

The optimal amount of effort that can be made is 7,000 trips year^{-1}. Meanwhile, effort data shows that the captures in 2020-2022 have exceeded the maximum effort that can be made. If the increase in fishing efforts continues, this will cause pelagic overfishing in the Sulamu District area. If the increase in fishing efforts continues, this will cause pelagic overfishing in the Sulamu District area (Zainun et al 2019; Hasrun et al 2021). Agus et al (2021) demonstrated an overfishing during the period of 2011-2015, concerning the yellowfin tuna in Bulukumba Regency. The production of skipjack tuna had decreased in Kupang, due to the fishing efforts exceeding the optimal level (Keo et al 2021). Hey (2012) states that waters near the coast are exploited on a large scale for fishing activities, so it is necessary to explore fishing areas located in deeper waters (oceans). In addition, it is necessary to reduce the fishing effort to increase pelagic fisheries production in the Sulamu region (Mereke & Mulugeta 2016; Kumar et al 2020).

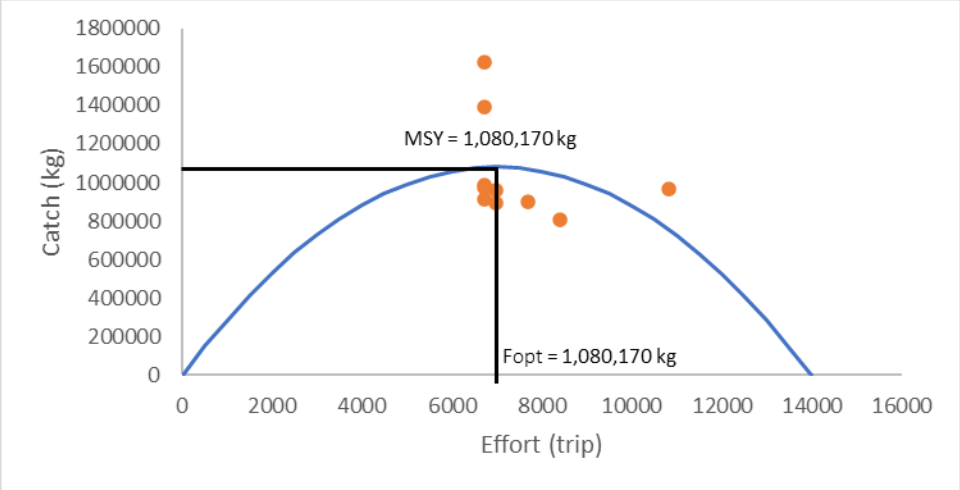

Figure 5. Relationship between catch and effort of pelagic fish capture in Sulamu District.

Conclusions. This study showed the potential amount of pelagic fish that can be caught in the Sulamu District area. Based on the results of the maximum sustainable yield calculation carried out, the potential for pelagic fishing in the Sulamu District area is 1,080,172 kg year^{-1}. The results showed that during the period 2013-2022, fishing production decreased due to an increase in fishing efforts. Based on the Schaefer Method, every additional effort of 1 unit will reduce the CPUE by 0.0221 kg. If the increase in fishing effort continues, it will cause overfishing of pelagic fish in Sulamu waters. Monitoring and limiting the number of fleets and fishing efforts is needed to prevent overfishing of pelagic fish in the Sulamu region.

Acknowledgements. The authors express profound gratitude to Mr. Dr. Ir. Damianus Adar, M.Ec as Chair of the Institute for Research and Community Service (LPPM) Nusa

Cendana University Kupang and his staff for the support provided and also the Sulamu District Fishermen who provided data for this research, together with The students who participated in the data collection process for this research.

Conflict of interest. The authors declare no conflict of interest.

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Received: 20 November 2023. Accepted: 26 February 2024. Published online: 16 March 2024.
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How to cite this article:
Kangkan A. L., Boikh L. I., Kiak N. T., Bolang R. T. C., 2024 The potential of pelagic fish resources in the waters of Sulamu District, Kupang Regency, Indonesia. AACL Bioflux 17(2):563-570.