ECSOFiM: Journal of Economic and Social of Fisheries and Marine. 2025. 13(01): 26-39 e-ISSN: 2528-5939
Permalink/DOI: http://dx.doi.org/10.21776/ub.ecsofim.2025.013.01.03

ECONOMIC POTENTIAL MANAGEMENT OF GROUPER RESOURCES IN KOLAKA REGENCY, SOUTHEAST SULAWESI, INDONESIA

PENGELOLAAN POTENSI EKONOMI SUMBER DAYA KERAPU DI KABUPATEN KOLAKA, SULAWESI TENGGARA, INDONESIA

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Received: April 29, 2025 / Accepted: September 20, 2025

ABSTRACT

Grouper is one of the fishery resources that has high economic value. The high price has led to increased exploitation of the grouper out of 163 grouper species worldwide. According to the IUCN, 12% (20 species) are classified as endangered, while 13% (22 species) are categorized as near threatened under the IUCN Red List criteria. This study aims to see the extent of the economic potential of grouper in Kolaka Regency and identify its distribution area. Analysis was done descriptively based on the results of field observations. The results of this research show that the potential of grouper fisheries in Kolaka Regency is quite large. However, the catch per unit of effort (CPUE) of grouper fluctuates every year. A significant increase occurred in 2014, then decreased in 2016, and increased again the following year; in 2017, there was a decrease in 2019, and increased again in 2020 and 2021. This research concludes that grouper fishing occurs more in the waters of Kolaka Regency due to the high fishing activities carried out by local fishermen. Based on these data, management efforts must be carried out immediately to maintain the stock of grouper resources in Kolaka Regency.

Keywords: fisheries, grouper, potential, management, economy.

ABSTRAK

Kerapu merupakan salah satu sumber daya perikanan yang memiliki nilai ekonomis tinggi. Tingginya harga tersebut menyebabkan peningkatan eksploitasi kerapu dari 163 spesies kerapu di seluruh dunia. IUCN menjelaskan bahwa 12% (20 spesies) terancam punah, dan 13% (22 spesies) dianggap hampir terancam berdasarkan kriteria Daftar Merah IUCN. Penelitian ini bertujuan untuk melihat sejauh mana potensi ekonomi kerapu di Kabupaten Kolaka dan mengidentifikasi wilayah penyebarannya. Analisis dilakukan secara deskriptif berdasarkan hasil observasi lapangan. Hasil penelitian menunjukkan bahwa potensi perikanan kerapu di Kabupaten Kolaka cukup besar. Namun, hasil tangkapan per unit usaha (CPUE) kerapu berfluktuasi setiap tahun. Peningkatan yang signifikan terjadi pada tahun 2014, kemudian menurun pada tahun 2016, dan meningkat lagi pada tahun berikutnya; pada tahun 2017 terjadi penurunan pada tahun 2019, dan meningkat lagi pada tahun 2020 dan 2021. Kesimpulan penelitian ini adalah bahwa penangkapan ikan kerapu lebih banyak terjadi di perairan Kabupaten Kolaka karena tingginya kegiatan penangkapan ikan yang dilakukan oleh nelayan setempat. Berdasarkan data tersebut, upaya pengelolaan harus segera dilakukan untuk menjaga stok sumber daya kerapu di Kabupaten Kolaka.

Kata kunci: perikanan, ikan kerapu, potensi, manajemen, ekonomi.

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INTRODUCTION

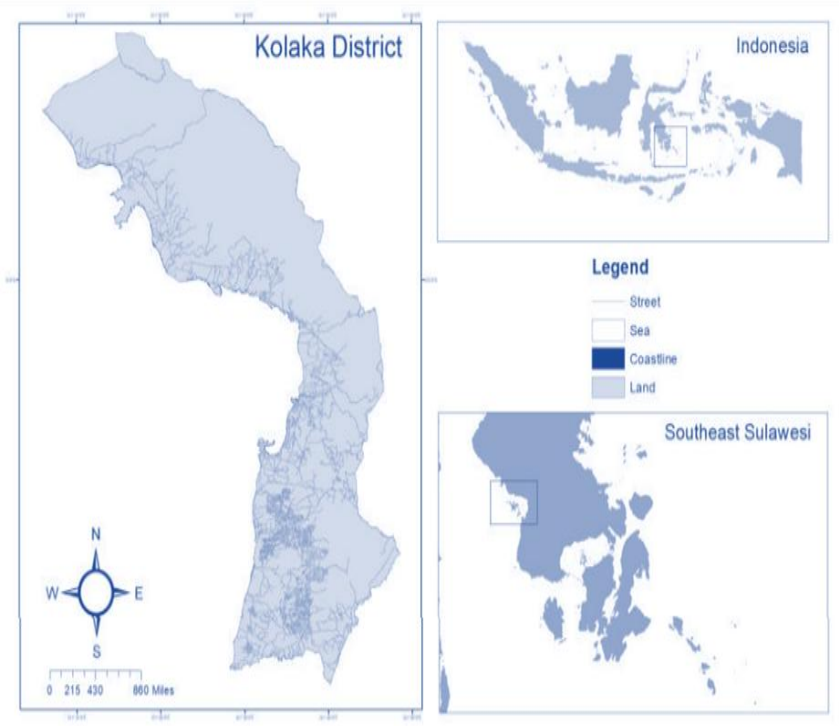
Grouper fish is one of the fishery resources that has high economic value. This fish is found living in coral reef waters (Razi et al., 2021). This fish is exported to various countries such as Singapore, Japan, Hong Kong, China, Malaysia, and the United States, with a price at the fishermen's level of IDR 70,000-150,000/kg for a 4-5 cm size. In live conditions, groupers are valued much more highly, so fishermen catch them very carefully. The grouper trade in Indonesia is growing very rapidly. In 1995, the catch was approximately 3,800 tons, and increased in 2024 to 30.352 tons (KKP, 2025). Based on data from the Director General of Fisheries Product Processing and Marketing (P2HP), grouper exports in 2024 reached 8.696,51 tons. The data shows that the level of grouper exploitation in Indonesia is quite high, supplying more than 50% of live reef fish caught to Hong Kong and Singapore, so that they are listed as exporting countries, especially the duck grouper (*Cromileptes altivelis*) and the giant grouper (*Epinephelus lanceolate*).

Xu et al. (2023) stated that the high demand has resulted in grouper being stressed and overfished, and some areas of the world have experienced overfishing. Grouper of the International Union for Conservation of Nature and Natural Resources (IUCN) is included in the endangered species. Research results in several areas in Indonesia, Hilyana et al. (2021), reported that the utilization of grouper resources in the Thousand Islands has exceeded the recommended optimal utilization rate (29.94 ton/year). The same thing was also obtained in the waters of Lasongko Bay, Buton Regency, Southeast Sulawesi, with the utilization rate exceeding the optimal condition (38.23 ton/year) (Razi et al., 2021; Prihantini et al., 2024). In general, grouper fisheries in Indonesia (Java, Sumatra, and Sulawesi) have experienced high-pressure resources that show significant signs of overexploitation.

Grouper fishing activities in Kolaka Regency from 2008 to 2011 experienced a decline in production (Syahrir et al., 2024). Most fishing in Kolaka waters is done by small-scale fishers. The description above can be understood that the management and utilization of fisheries resources is an important thing and is the obligation of all stakeholders. Playing a role in fisheries management efforts as an effort to manage fisheries managed by fishermen can improve welfare, so that the availability of fisheries resources can be controlled sustainably. Therefore, research is needed that aims to analyze the potential for sustainability in the waters of Kolaka Regency, Southeast Sulawesi Province.

RESEARCH METHODS

The research location is in the waters of Kolaka Regency, a coastal area whose livelihood is grouper fishing. The research will be conducted for eight months, starting from April 2022 to November 2022. The research location can be seen in Figure 1.



Source: Research Team Data (2022)

Figure 1. Research Locations Kolaka Regency

The type of data used consists of primary and secondary data. Primary data is obtained directly at the grouper fishing location and interviews with key informants; secondary data is data obtained from agencies related to grouper potential. As well as data collection instruments used in the research: interview guidelines and cameras for supporting documentation.

Analysis of grouper conservation potential and utilization rate using descriptive analysis and MSY analysis. Descriptive analysis is a statistical analysis method that aims to provide a description of the subject of research based on variable data obtained from a particular subject group. This method helps in describing, demonstrating, or helping to summarize data points so that those patterns can develop that satisfy all data conditions. Descriptive research is a research method whose writing seeks to describe the subject or object it examines in more depth, detail, and breadth.

Estimating Grouper Catch Productivity in Kolaka Regency

Fishing gear productivity is commonly assessed through the calculation of CPUE. In this study, CPUE was determined by dividing the total catch by the standardized measure of fishing effort. The CPUE values were derived from secondary data recorded on a monthly basis over a five-year period, spanning 2015 to 2021. Referring to Gulland (1983), the formula for calculating CPUE is presented in Equation 1.

$$CPUE = \frac{\sum Catch_t}{\sum Effort_t} \quad (1)$$

Where:

$CPUE_t$ = Catch Per Unit Effort (ton/year/unit)

$Catch_t$ = Amount of catch (ton/year)

$Effort_t$ = number of arrest attempts (unit)

t = year (1,2,3, …., n)

Maximum Sustainable Yield Estimation of Grouper Resources in Kolaka Regency

To estimate maximum sustainable yield (MSY) from grouper catch and fishing-effort data, common options include the Schaefer, Fox, and Walter–Hilborn models. The present study employs the Gordon–Schaefer linear model, as given in the following equations.

1. The relationship between CPUE and effort (f).

$$CPUE = a + bf \tag{2}$$

From the linear relationship between CPUE and effort (f), obtain that a = intercept, and b = slope.

2. The relationship between catch and effort.

$$\frac{C}{f} = a + bf \tag{3}$$

$$C = af + bf^2 \tag{4}$$

3. To obtain the optimum effort (f_{opt}), the first derivative of the catch (C) in relation to effort is set to zero.

$$C = af + bf^2 \tag{5}$$

$$C' = \frac{dC}{df} = a + 2bf = 0 \tag{6}$$

$$2bf = -a \tag{7}$$

$$f_{opt} = -\frac{a}{2b} \tag{8}$$

4. To get the MSY value, substitute the optimum effort value (f_{opt}) into equation (8).and get the MSY formula in equation (12).

$$C_{max} = a\left(\frac{-a}{2b}\right) + b\left(\frac{a^2}{4b^2}\right) \tag{9}$$

$$C_{max} = \left(\frac{-a^2}{2b}\right) + \left(\frac{a^2}{4b}\right) \tag{10}$$

$$C_{max} = \left(\frac{-2a^2 + a^2}{4b}\right) \tag{11}$$

$$MSY = C_{max} = \left(\frac{-a^2}{4b}\right) \tag{12}$$

Analysis of the Distribution of Grouper Fishing in Kolaka Regency

Furthermore, this research also analyzed spatial maps of the distribution of grouper fishing areas based on information from grouper fishermen in the waters of Kolaka Regency, Southeast Sulawesi, using an online Google Earth application based on Rijal & David (2021).

RESULTS AND DISCUSSION

Brief Description of Grouper Fish

Groupers (Figure 2), belonging to the Serranidae family, inhabit tropical and subtropical regions, particularly coral reef ecosystems, mangrove forests, and muddy coastal waters. Internationally, they are referred to as groupers, trout, rockcod, hinds, sea basses, or coral reef fish. According to Giménez-Hurtado et al. (2005), this family consists of 15 genera and 159 species. Among them, the genera *Cromileptes*, *Plectropomus*, and *Epinephelus* are the three most widely cultivated for commercial purposes. Their distribution extends across the western Pacific, from southern Japan to Guam, New Caledonia, the southern islands of Australia, and the eastern Indian

Ocean. In Indonesia, they are commonly found in areas such as Banten Bay, Ujung Kulon, the Riau Islands, the Seribu Islands, the Karimunjawa Islands, Maluku, Kalimantan, Sulawesi, and Nusa Tenggara (Razi et al., 2021).



Source: Research Team Data (2022)

Figure 2. Grouper Fish (*Plectropomus leopardus*)

Groupers are protogynous hermaphrodites, meaning their gonadal development begins in the female phase and later transitions to the male phase. In other words, they start life as females and change into males once they reach a certain size. This sex change typically occurs when the fish attains a total length of 42–62 cm, with maturity reached in about 2–3 years at a body weight of more than 2.5 kg. The sunu grouper is considered a valuable export commodity due to its high market price. In Indonesia, two highly prized species of sunu grouper are *Plectropomus leopardus* (leopard coral trout) and *Plectropomus maculatus* (barred-cheek coral trout). Among the *Plectropomus* genus, the red grouper (*P. leopardus*) is the most commonly cultivated species and commands a relatively high selling price. In 2010, the price of live *P. leopardus* reached approximately US$30–$50 per kilogram.

Waters with environmental conditions of 24–31°C, salinity levels of 30–33 ppt, dissolved oxygen above 3.5 ppm, and a pH range of 7.8–8.0 are considered optimal for grouper growth. Reproduction in groupers typically occurs through mass spawning aggregations involving dozens to thousands of individuals (Xu et al., 2023). These aggregations often take place in consistent locations and at predictable times over long periods, making them highly susceptible to fishing pressure. When spawning grounds continue to be exploited, reproductive success may be disrupted, particularly due to reduced male abundance, which limits sperm availability. According to Catalano and Allen (2013), reproduction and recruitment represent critical stages in the fish life cycle, as they are closely linked to spatial movements, with some species migrating to specific spawning grounds. Fish populations are especially vulnerable to fishing impacts in spawning and nursery habitats, where both broodstock and juveniles are concentrated (Razi et al., 2021).

Potential of Marine and Fishery Resources in Kolaka Regency

Coastal communities in Kolaka Regency have long utilized grouper (*Plectropomus leopardus*) as a source of food and income, as long as the market is of high value (Mous et al., 2005). Intensive fishing will result in pressure on local resources, resulting in increased stock numbers, and may lead to overfishing. Conducting management requires strong scientific and analytical stock-based information to make appropriate management measures (Hernandez & Seijo, 2003). The results of the Kolaka Regency Fisheries Service report stated that the production of grouper fishery commodities has decreased from 2015 to 2020 by 45%. This can be caused by a lack of supervision and control of resources, resulting in a decrease in fish stocks (Prihantini et al., 2022).

Kolaka Regency's potential sources of marine and fisheries personnel are quite large, including marine, land, and aquaculture personnel (Prihantini et al., 2022). This regency has 13 (thirteen) small fruit islands, namely: P. Padamarang, P. Lambasina Kecil, P. Lambasina Besar, P. Buaya, P. Pisang, P. Maniang, P. Lemo, P. Kukusan, P. Lamburoko, P. Campea, P. Ijo, P. Lima, P. Batu Mandi, with very large islands of 4,384 Ha. These conditions are very supportive of fisheries sector development activities that capture and cultivate marine organisms, such as pearl shell cultivation on Lambasina Kecil Island and Lambasina Island, as well as other sectors, such as mining and tourism on Padamarang Island, which is a national park area and natural marine tourism. Based on the potential of fisheries resources in Kolaka Regency, it can be seen in Table 1.

Table 1. Potential Source Power Fisheries & Levels of Utilization in Kolaka Regency, 2021

No.	Potency	Sustainable Potential (tons/year)	Utilization Rate	
			Volume (tons/year)	%
1	Waters Sea	37,500	19,700.70	52.50
2	Waters General	10,000	213.30	2.10
3	Brackish Water Cultivation	8,500	4,643.36	20.80
4	Freshwater Aquaculture	6,000	369.43	7.05
5	Cultivation Sea	7,000	27.73	8.80

Source: Processed from DKP Data, Kolaka Regency (2022)

Kolaka Regency fisheries production for all types of waters and aquaculture activities tended to fluctuate from 2015 to 2021. In 2021, the utilization rate reached 52.5% of the estimated sustainable potential of 37,500 tons per year. Aquaculture production in general seems to be at its lowest point among all categories. It was 2.1% from 10 thousand tons (sustainable potential production). The utilization rate of brackish water aquaculture reached 20.8% of its total sustainable potential of 8,500 tons. Freshwater aquaculture production amounted to 6,000 tons, with a utilization rate of only 7.05% that year. Marine aquaculture production continued to grow annually, peaking in 2021 at 27.73 tons and achieving a utilization rate of 8.8%. Further information on fisheries production trends in Kolaka Regency from 2015 to 2021 is presented in Table 1. Overall, the utilization of fisheries resources in Kolaka Regency remains below its full potential.

Maximum Sustainable Yield of Grouper Resources in Kolaka Regency

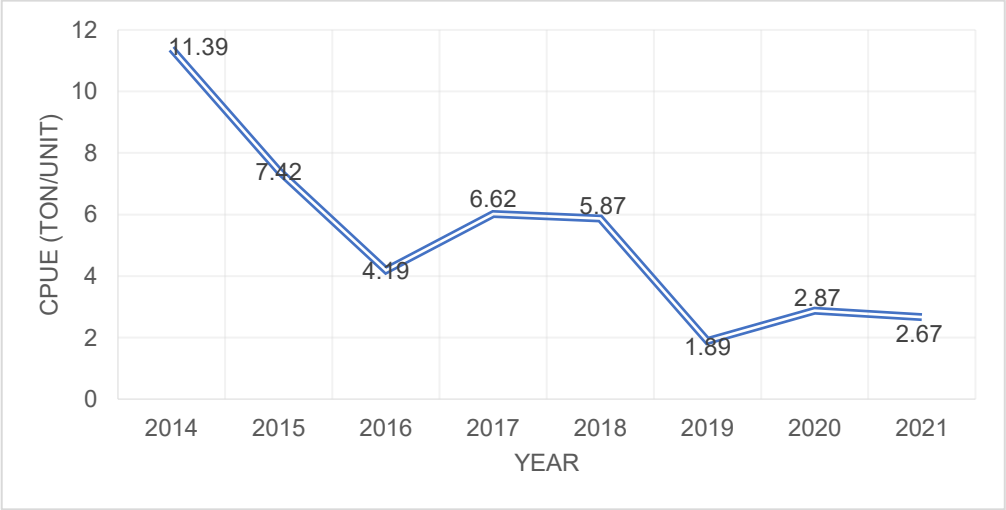
The calculation of CPUE is widely applied to assess fish stock dynamics and serves as an indicator of fishing potential and operational efficiency, requiring less data compared to other approaches (Xu et al., 2023). CPUE is measured by dividing the catch by the standardized fishing effort. In this study, the main fishing gear utilized includes traps and handlines. As shown in Table 2, CPUE values exhibit a declining trend, especially from 2015 to 2019. This reduction reflects the overexploitation of grouper resources in Kolaka waters. According to Putri et al. (2023), a decline in CPUE signals overfishing of fish resources. Moreover, a falling CPUE also suggests reduced efficiency in fishing operations, as greater effort results in smaller catches.

Table 2. Production values, efforts, and CPUE of grouper fish in Kolaka Waters (2015-2021)

Year	Effort (unit)	Production (ton/year)	CPUE (ton/year/unit)
2015	391	2,901.22	7.42
2016	428	1,793.32	4.19
2017	604	3,636.08	6.02
2018	662	3,885.94	5.87
2019	737	1,392.93	1.89
2020	795	2,281.65	2.87
2021	871	2,325.57	2.67

Source: Processed from DKP Data, Kolaka Regency (2022)

The catch per unit of effort (CPUE) of grouper in Kolaka Regency fluctuates every year. A significant increase occurred in 2014, then decreased in 2016 and increased again the following year, 2017, decreased in 2019, and increased again in 2020 and 2021 (Figure 3). Figure 3 shows that fishermen can obtain high yields in a given year and then simultaneously increase fishing effort, but this is followed by a reduced yield increase in subsequent years because the resource has been reduced. Giménez-Hurtado et al. (2005) said that catches characterized by MSY (maximum sustainable yield) obtained from resource stocks are not expected to affect reproduction and recruitment.



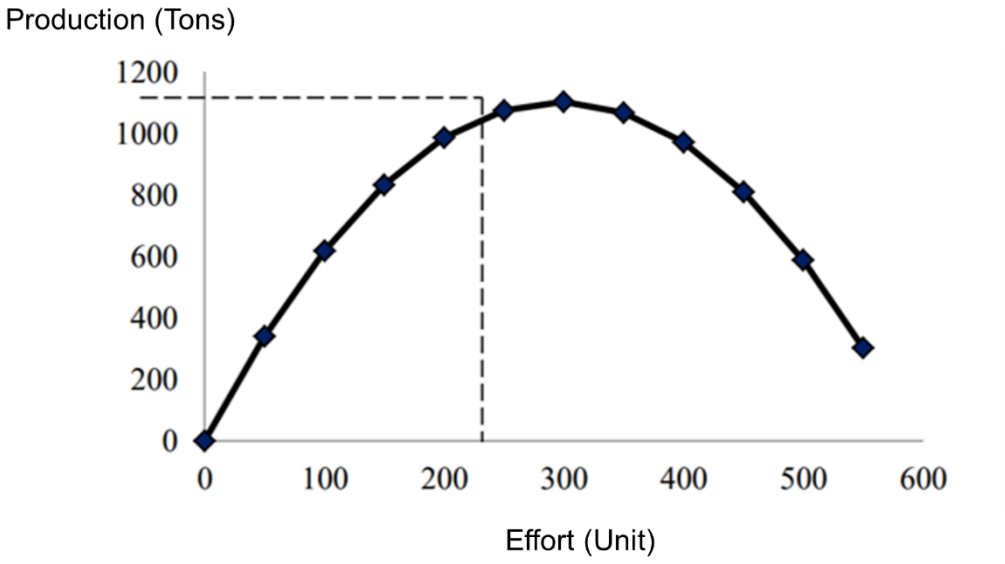
Source: Processed from Primary Data (2022)

Figure 3. Grouper's CPUE in the Waters of the Kolaka Regency (2015-2021)

Through the simple regression method between CPUE (Schaefer model) and standard effort, the regression coefficient and coefficient of determination (R^2) for grouper were obtained. It can be

seen that the R^2 value for the Schaefer model is 0.8. This value was used in the MSY calculation. The purpose of using the surplus production model is to determine the optimal level of effort, which is a productive effort that produces maximum and sustainable catches. This method is widely used in tropical waters because it only uses catch per unit of effort (CPUE). Surplus production is based on the assumption that each type of fish in one year will produce a surplus amount (Soede et al., 1999). Captured, and if caught, the resulting surplus becomes a resource that will remain sustainable. The relationship between fishing effort and yield shows an asymmetrical parabolic curve; the catch will increase with increasing effort until it reaches a maximum point, and then decrease even with additional effort (Vrijenhoek, 1998).

The more exploitation, the greater the level carried out through additional efforts, such as the addition of fishing gear and vessels, will not increase the catch but instead will reduce the stock, so that the results obtained will decrease from year to year. This will have an impact on the amount of production costs incurred with minimal profit, so that fishermen will experience losses in terms of finance and time. This condition will also result in the grouper population being overfished. For more details on the relationship between the fishing effort curve and production, see Figure 4.



Source: Processed from Primary Data (2022)

Figure 4. Curve Connection between Production and Effort of the Schaefer Model

The maximum sustainable yield (MSY) or maximum sustainable catch (Indonesian: Hasil Tangkap Maksimum Lestari or HTML) of grouper in the waters of Kolaka Regency is 1,103 tons using the precautionary approach. The Ministry of Marine Affairs and Fisheries determined the amount of allowable catch (*Jumlah Tangkapan yang Diperbolehkan*/JTB in Indonesian) is 80% of MSY. Based on the calculation of the results, the JTB of grouper fish in the waters of Kolaka Regency is 882 tons per year with 297 business units. Based on the JTB value, the number of fishermen caught has exceeded the allowable catch from 2016 to 2021. This resulted in high exploitation in the waters of Kolaka Regency by 70%. Kerber et al. (2012), Kurniawan et al. (2022); Haerunnisa et al. (2025) stated that fisheries resource management aims to achieve fishermen's welfare, provide food and raw materials, generate industrial foreign exchange, and determine the optimal portion of the

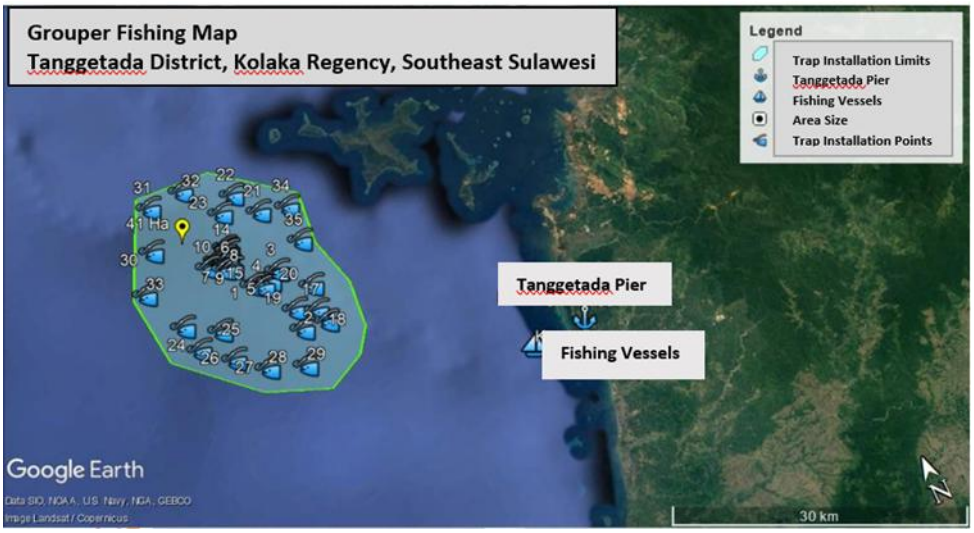
utilization of fishing products. In addition, fisheries management also controls the amount of catch allowed based on the maximum sustainability of the catch (William et al., 2008; Sudirman et al., 2025).

Fishery resources are common property; that is, the utilization of resources can be used at the same time by more than one individual (Xu et al., 2023; Zeller et al., 2008). Therefore, in this type of business, the utilization to provide a relative level of profit will increase the vital utilization pressure, so that if it is not regulated in good faith, it tends to cause excessive utilization and does not rule out the possibility of a threat to the continuity of the business itself. Mahe et al. (2022) stated that the challenge of maintaining sustainable resources is a complex issue in fisheries development. However, fisheries resources are categorized as recoverable resources. The question that often arises is how many large fish can be caught without having to cause negative impacts in the future (Giménez-Hurtado et al., 2005; Arreguín-Sánchez, 2000; Ehrhardt & Deleveaux, 2007; Nandita et al., 2021).

The potential of marine fisheries is indeed a considerable asset for Indonesia's economic growth. However, this asset still needs to be maximally utilized. The potential of marine fisheries includes capture fisheries, mariculture, and the marine biotechnology industry. According to Albañez-Lucero & Arreguin-Sanchez (2009) and Arreguín-Sánchez (2000), Indonesia's marine fisheries potential reaches 6.4 million tons per year, with an allowable catch of 5.2 million tons or 80% of MSY. To date, the catch has reached 4.7 million tons (KKP, 2025). The world's population is increasing rapidly, so the demand for food, including fish, is also increasing. To maintain or restore species at maximum sustainable yield (MSY) levels, countries should regulate allowable catches based on scientifically designed information (Kristiana et al., 2021; Haerunnisa et al., 2025).

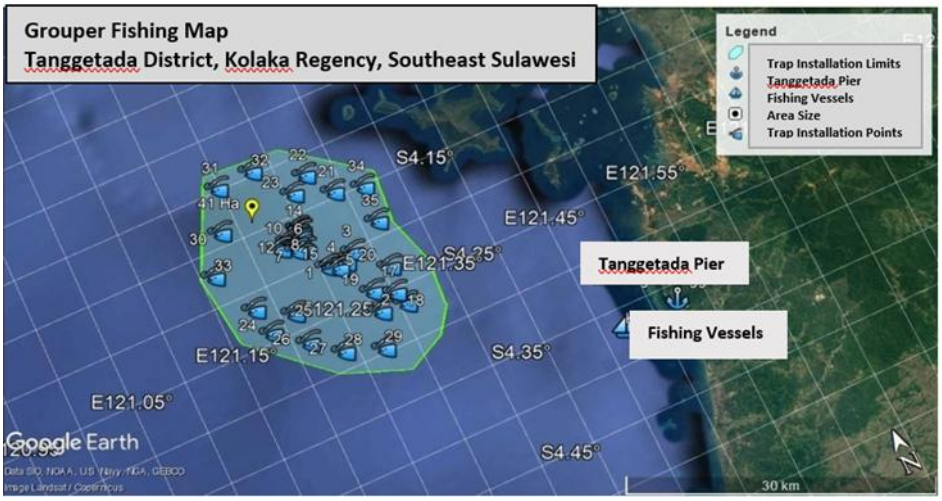
Distribution of Grouper Fishing in Kolaka Regency

The locations for grouper fishing are determined based on where trap fishing gear is set up. Traps are used because groupers are demersal fish that inhabit the sea bottom and are closely associated with coral reefs. Monitoring efforts recorded 35 trap installation sites. These coordinates were mapped using a GPS device mounted on the vessel (Figure 7). The 35 trap sites were located at depths of approximately 50–60 meters, as shown in Table 3. Using GPS to map coordinate points, data on trap installation locations in the waters of Kolaka, Tanggetada District, was collected. The plotted coordinates were input into the Google Earth application, allowing for the identification of grouper fishing sites. Based on data gathered from the fishing vessel, the grouper fishing area covers approximately 41 hectares, as shown in Figure 5 and Figure 6. Additionally, the Google Earth application can be utilized to assess the suitability of mariculture areas for grouper farming (Rijal & David, 2021). Similarly, Rosmasita et al. (2020) employed Google Earth for the mapping and monitoring of fixed net distributions.



Source: Research Team Data (2022)

Figure 5. Map of Grouper Fishing Locations in Tanggetada Waters



Source: Research Team Data (2022)

Figure 6. Map of the Distribution of Trap Installation Points Based on Latitude



Source: Research Team Data (2022)

Figure 7. Field Equipment when Installing Traps on a Ship

The grouper fishing distribution map for the Tanggetada waters was created based on the coordinate points where fishermen installed their fishing gear in the Tanggetada area of Kolaka Regency. The fishing gear used consists of bottom traps placed on the seabed. The installation process involves the use of a winch system that lowers the traps into the water and retrieves them after being left submerged for several days. GPS devices are used to mark and record the exact locations of the traps. The traps are specially designed for ease of use and are made from environmentally friendly materials.

Table 3. Distribution of Coordinate Points for Installing Fishing Traps in Kolaka Waters

No.	Latitude	Longitude
1.	-4.215490°	121.252620°
2.	-4.272790°	121.278050°
3.	-4.212522°	121.279091°
4.	-4.220704°	121.260741°
5.	-4.218380°	121.268337°
6.	-4.192422°	121.241121°
7.	-4.190401°	121.234601°
8.	-4.189592°	121.239548°
9.	-4.183734°	121.239548°
10.	-4.182623°	121.221633°
11.	-4.181613°	121.231612°
12.	-4.179390°	121.230990°
13.	-4.171411°	121.243637°
14.	-4.175350°	121.244748°
15.	-4.216259°	121.256659°
16.	-4.174845°	121.244345°
17.	-4.262306°	121.297166°
18.	-4.275452°	121.301483°
19.	-4.252866°	121.279149°
20.	-4.238571°	121.302548°
21.	-4.153754°	121.286224°
22.	-4.128615°	121.269619°
23.	-4.140342°	121.252864°
24.	-4.224473°	121.177903°
25.	-4.242170°	121.208179°
26.	-4.250498°	121.183212°
27.	-4.272077°	121.208991°
28.	-4.292474°	121.233740°
29.	-4.304853°	121.266957°
30.	-4.146683°	121.179402°
31.	-4.107079°	121.193601°
32.	-4.105150°	121.227472°
33.	-4.181589°	121.157690°
34.	-4.160617°	121.312494°
35.	-4.195231°	121.310229°

Source: Research Team Data (2022)

CONCLUSION AND SUGGESTION

Conclusion

Grouper populations in the waters of Kolaka Regency have been subjected to overfishing, with an exploitation rate reaching 70%. Effective management measures are necessary to restore the stock to optimal levels, including setting an allowable catch (JTB) limit of 882 tons per year and maintaining an optimum fishing effort of 297 trap units. Catches should ideally exceed the first gonadal maturity size of 69.5 cm. The mapping of grouper fishing locations in Kolaka Regency focused on the waters of Tanggetada District. Field investigations identified 35 fishing sites, distributed at depths of approximately 50–60 meters. The fishing area covers about 41 hectares, determined by the distribution of traps placed on the seabed.

Suggestion

Efforts to manage grouper resources must take into account sustainability aspects, such as restricting the wild capture of fish fry and implementing a water zoning system. This is important in order to preserve grouper resources in Kolaka Regency for future generations.

ACKNOWLEDGEMENT

This research was funded by LPPM of Universitas Sembilanbelas November Kolaka 2021. The authors would like to express their deepest gratitude to all of the respondents (fishermen of Tanggetada) and LPPM of Universitas Sembilanbelas November Kolaka, for the facilities and equipment that greatly assisted this research.

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