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Sustainability Analysis of Fish Resources and Fishing Technology at Palabuhanratu Nusantara Fishing Port, West Java, Indonesia

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Abstract
The domain of fish resources and fishing technology has several aspects that can be used as indicators of overfishing in a certain water area. It is very important to know in fisheries management so that the process can run optimally and sustainably. This study uses EAFM as a tool to assess the sustainability of fish resources and fishing technology in Palabuhanratu Nusantara Fishing Port. The data were obtained from interviews and questionnaires given to fishermen representing the capacity and size of their vessels. The results show that in the fish resource domain, there are two indicators that have low sustainability values, namely the Catch per Unit Effort (CpUE) and the proportion of juvenile fish. While in the domain of fishing technology, indicators that have less sustainability value are modification of fishing gear and fishery capacity. The low values of these four indicators indicate that there is a tendency for overfishing around these waters so that control efforts are needed to be more sustainable.

Keywords: Fish Resources, Fishing Technology, Palabuhanratu Fishing Port

1. Introduction

As the largest archipelagic country in the world, Indonesia has a very high potential for marine and fisheries products. Based on statistical data from the Ministry of Marine Affairs and Fisheries of the Republic of Indonesia (2019) [3], "the potential for fish resources in Indonesia or Maximum Sustainable Yield (MSY) in 2017 reached 12.54 million tons or an increase of 71.78 percent from 2015 which amounted to 7, 3 million tons. Compared with the potential and the amount of catch allowed, the average utilization rate of capture fisheries resources in Indonesia reaches 0.90 or is included in the fully exploited category, which means that fishing efforts are maintained with strict monitoring (Agustian, 2022) [1]. Based on the fisheries management area, of the 11 WPP-NRI in Indonesia, WPP-NRI 711 which includes the Karimata Strait, Natuna Sea, and South China Sea is the area with the highest utilization rate of capture fisheries resources, reaching 1.07 and is included in the category. Over-exploited, while the area with the lowest utilization of capture fisheries resources is in WPP-NRI 572 which includes the waters of the Indian Ocean west of Sumatra and the Sunda Strait with a utilization rate of 0.65 which is included in the fully-exploited category (Agustian *et al*., 2021) [2]. The high level of utilization of fishery resources should also be accompanied by an increase in fishermen's welfare. However, in reality, this fisherman is one of the social groups of the population or community who have been marginalized both socially, economically and politically, identified as poor and having the lowest income apart from farmers (Anwar *et al*., 2019) [3]. This indicates that the fisheries management process in our country has not been carried out optimally by implementing the principles of sustainable fisheries management. Whereas as the largest tuna producing country in the world, and contributed 15% to global tuna production in 2009 (Miyake *et al*., 2010; Sunoko & Huang, 2014) [9, 17] Indonesia must play a central role in safeguarding the world's pelagic and coastal biomass (Pertiwi *et al*., 2017) [14].

In addition, from an environmental aspect, the development of coastal areas to support the activities of the fishing, tourism and trade industries still does not pay attention to environmental quality. In this context, FAO has explained several principles that must be considered in implementing fisheries management with an ecosystem approach (EAF), namely: "(1) fisheries must be managed at limits that have an impact that the ecosystem can tolerate; (2) the ecological interactions between fish resources and their ecosystems must be maintained; (3 management tools should be appropriate and can be used for all distribution of fish resources; (4) precautionary principles in the fisheries management decision-making process; and (5) fisheries governance includes the interests of ecological systems and human systems". The ecosystems that become their habitats, and the processes associated with them are the main studies in EAFM. However, the studies in EAFM do not stop there, but also discuss the relationship between fishing activities and the ecosystem as a whole, including social impacts and the resulting economy

(FAO, 2021) [6].

According to Charles (2001) [5], there are three dimensions in sustainable fisheries management that cannot be separated from each other, namely "(1) the dimensions of fishery resources and their ecosystems; (2) the dimensions of the utilization of fishery resources for the socio-economic interests of the community; and (3) the dimensions of fisheries policy itself". Related to these three dimensions, the current condition of fisheries management must pay more attention to the balance between the three, especially in terms of the socio-economic interests of the community, in this case fishermen. One of the main factors that can ensure the sustainability of fisheries management by fishermen is related to the condition of fish resources available in these waters. There are several indicators used to assess the condition of fish resources, namely standard CpUE, fish size trends, proportion of juvenile fish, fish composition, range collapse, and ETP species. Utilization of fish resources in waters will certainly be closely related to the use of fishing technology by fishermen, so that these two factors become the focus of assessment in this study.

It is hoped that by considering the aforementioned matters, it will be able to provide a more comprehensive EAFM assessment to describe the sustainability level of fish resources and fishing technology in an integrated area that has been determined by the government, especially fishing ports. So that the results of this study can be used as an early warning for stakeholders as an effort to ensure the sustainability of fisheries management in the region.

2. Material and Methods

The method used in this research is a survey method using composite analysis and flag modeling visualization techniques. This method will assess the EAFM indicator of fish resources and fishing technology domain as a multicriteria system that ends in a composite index in the form of a score of values related to the level of achievement or sustainability of fisheries management in accordance with EAFM principles. The composite value and the flag model have their respective descriptions that indicate the level of EAFM application in fisheries management activities, or in other terms indicate the status of the sustainability of fisheries management in the region or area.

Table 1: Visualization of the flag model for EAFM indicators

Composite Value	Flag Model	Description
1 – 21		Poor
22 – 41		Less
42 – 60		Moderate
61 – 80		Good
81 - 100		Excellent

Source: Agustian (2022) [1]

The sampling technique used in this study was purposive sampling and proportional sampling. Primary data obtained from the results of field observations, questionnaires and interviews with respondents from various stakeholders in PPN Palabuhanratu, namely fishermen, port managers, and entrepreneurs who run their business at PPN Palabuhanratu. In addition, secondary data is obtained from annual statistical reports, fishery logbooks, and other relevant reports.

3. Results and Discussion

Discussions about fishing technology will certainly not be separated from the use of fishing gear by fishermen to catch fish in these waters. Based on the results of observations in the field, there are several types of fishing gear used by fishermen in Palabuhanratu Archipelagi Fishing Port, as described in Table 2 below.

Table 2: Number and Type of Fishing Equipment Used Based on Vessel Size at Palabuhanratu Archipelagi Fishing Port

S. No	Type of Vessel	Type of Fishing Gear	Vessel size	Number of Fishing Gear	Average/Month
1.	Outboard boat	Hand line	-	1.642	137
		Shrimp entagling gillnet	-	329	27
		Pelagic dannish seinne	-	525	44
		Trammel Net	-	238	20
Sub-total				2.734	228
2.	Motor boat	Lift net	5-20 GT	204	17
		Shrimp entagling gillnet	5-20 GT	53	4
		Troll line	5-20 GT	460	38
		Shrimp entagling gillnet	20-30 GT	6	1
		Tuna Long Line	20-30 GT	22	2
			30-50 GT	95	8
			50-100 GT	78	7
Sub-total				935	78
Total				3.669	306

Source: (Agustian, 2022) [1]

Based on the results of the assessment of the two domains, namely the domain of fish resources and fishing technology, a composite value is obtained which indicates the level of sustainability in fisheries management as shown in Table 3 below.

Table 3: Result of indicator assessment for fish resources and fishing technology domain at Palabuhanratu Nusantara Fishing Port

S. No	Domain	Composite Value	Flag Model	Category
1	Fish resources			
	a. CpUE	33,33		Less
	b. Fish size trends	66,67		Good
	c. Proportion of yuwana fish	33,33		Less
	d. Species composition	100		Excellent
	e. Range collapse	66,67		Good
	f. ETP species	79,67		Good
	Average	63,28		Good
2	Fishing technology			
	a. Destructive and illegal fishing	100		Excellent
	b. Fishing gear modification	33,33		Less
	c. Fishing capacity	33,33		Less
	d. Selectivity of fishing	100		Excellent
	e. Suitability of ship size with legal document	100		Excellent
	f. Crew certification	66,67		Good
	Average	72,22		Good

Fish Resources

The fish resource domain is a domain in EAFM whose indicators are most closely related to indicators in other domains. In other words, many other domains are highly dependent or influenced by conditions in the fish resource domain. This can be seen from the highest density value among other domains as shown in Table 3. The composite value for the Fish Resource Domain was obtained from an assessment of several indicators, namely standard CpUE, trend of fish size, proportion of juvenile fish, catch species composition, range collapse of fish resources, and ETP species. Data mengenai berbagai indikator ini menjadi salah satu informasi penting yang dapat mempengaruhi ketersediaan stok ikan dalam keberlanjutannya (Nuralam *et al*., 2023) [13].

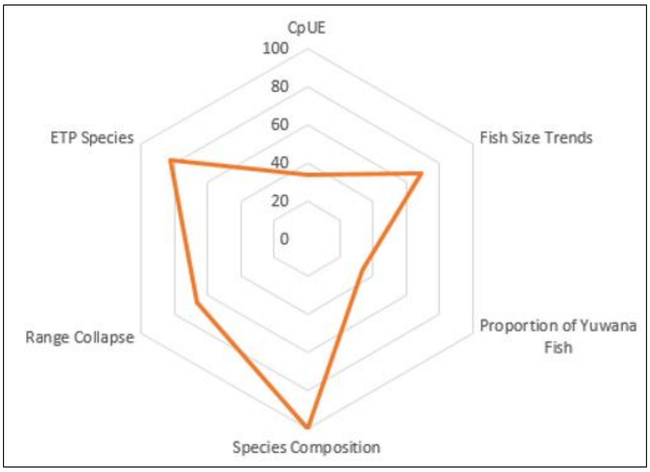

Fig 1: Chart of composite value for fish resources domain in EAFM

CpUE

Catch per Unit Effort (CpUE) is defined as the annual catch rate of fisheries obtained using time series data for at least the last 3 years. The measurement of the CpUE indicator aims to determine the productivity and abundance index of fish, detect fishing capacity, determine fishing pressure, and how the trend of changes in fish stock status in a particular area. This low CpUE value indicates that there is an indication of a tendency to have a negative impact on fish stocks due to pressure on the ecosystem due to increased fishing activities. In simple terms, the level of effectiveness of fishing by fishermen is low because the increase in fishing effort is not accompanied by an increase in commensurate catches. Therefore, fishing efforts must be controlled so as to provide opportunities for fish to grow and reproduce.

Fish Size Trends

Assessment of this indicator aims to determine the pressure of fishing activities, see fishing patterns, and determine population parameters. The measurement is carried out through fishery logbook analysis by comparing the average weight of fish caught during the last 4 months in 2019 in the Palabuhanratu Nusantara Fishing Port logbook. The types of fish that were collected were Bigeye Tuna (*Thunnus obesus*), Yellowfin Tuna (*Thunnus albacares*), Layur Fish (*Trichiurus lepturus*), Skipjack Tuna (*Katsuwonus pelamis*), and Lisong Tuna (*Auxis rochei*). These five types of fish are the main commodities of fishery products in Palabuhanratu PPN, because the percentage of catches of these five types of fish reached almost 50% of the total catch in 2019. Analysis of fish size trends is very important to determine the tendency of overfishing in these waters. If there is a decreasing trend in fish size, it is indicated that there is excessive fishing activity in the area because fish are not given the opportunity to grow. Besides being able to affect the level of sustainability of fish resources in the area, the trend of decreasing fish size will also affect the economic value obtained by fishermen because the fish they catch have not reached the ideal weight or size to get the best selling price. In fact, most of the bigeye tuna and yellowfin tuna caught in the waters of the Indian Ocean (about 39%) are categorized as immature fish (Agustian, 2022; Suman *et al*., 2015) [1, 16].

Proportion of Yuwana Fish

The assessment of juvenile fish proportion indicators aims to determine the fishing pressure and stock of fish that are ready to spawn. In general, fishermen who catch fish in the sea will definitely take every catch as long as it is considered valuable regardless of size or type. Whereas the regulation regarding the size and type of fish that can be caught will affect the availability of fish stocks and the sustainability of their livelihoods. Insufficient or small assessments for this indicator indicate that there is a threat to sustainable fisheries management, because juvenile fish stocks that should be allowed to continue to develop into adults and productively breed, continue to decrease. So that with the decrease in productive fish, the fish stock in the future can certainly continue to decrease.

Species Composition

This indicator assessment aims to measure the ratio of target fish and non-target fish (bycatch) that have been caught and utilized by fishermen and to identify changes in the diversity or diversity of catches. This composition comparison refers to the level of selectivity of the fishing gear used by fishermen. So if the proportion of non-target fish is more than the target fish, it can be said that the fishing gear used is not selective. These results indicate that the fishing gear used by fishermen in Palabuhanratu PPN is very selective towards the desired target fish. In other words, the proportion of non-target fish (bycatch) that may be of little value or even not utilized by fishermen is very small, so that the proportion in the aquatic ecosystem can be maintained. The existence of non-target fish is very important for sustainable fisheries management because it has a role (niche) as a consumer and prey for target fish, so that if the number decreases, it will cause an imbalance in the ecosystem, including the survival of the target fishes.

Range Collapse

This indicator is assessed to determine the impact on fish resources due to increased pressure in fishing. This pressure can be in the form of increased fishing effort by fishermen or pressure due to the number of catches that are not managed responsibly. The indicator to assess this range collapse is to identify whether there is an additional fishing ground space that must be taken by fishermen. According to the study's findings, fishermen did not add any new fishing spots or make any substantial alterations to existing ones. This shows that fishing operations do not exert a significant amount of strain on fish habitat.

ETP Species

This indicator for ETP Species shows the presence or absence of species belonging to the ETP category that are caught by fishermen either as non-target (bycatch) or as main targets. The measurement results of this indicator are useful for knowing the level of ecosystem quality, so that the more diverse types or species of fish and other fishery commodities that are caught, the better the quality of the ecosystem. If more and more species belonging to ETP are caught by fishermen, it is feared that it will disrupt the balance of the aquatic ecosystem itself, because we know that each organism must have its own niche in its ecosystem. For example, sharks play a role in maintaining the balance of the ecosystem by eating marine animals that are weak or sick so that the health of the marine ecosystem is maintained (DKP Aceh, 2019). Even the absence of sharks in marine ecosystems can cause the decline and damage to coral reefs, seagrass beds, and loss of commercial fish commodities (Motivarash & Dabhi, 2020). Another example is turtles that can maintain the health of coral reefs by eating sponges that compete with coral reefs, controlling the number of jellyfish in the ocean, and maintaining the health of the seagrass ecosystem (Lovich *et al*., 2018; Pratama *et al*., 2021) [8, 15] which is very useful as a breeding ground. ground, nursery ground, and feeding ground for various marine biota. Most bycatch, such as billfish and other bony fish, sharks, various types of turtles, and marine mammals, are considered apex predators playing an important role in the structure and function of all marine ecosystems (Ferretti *et al*., 2010; Morgan & Sulikowski, 2015) [7, 10].

Fishing Technology

The assessment of the Fishing Technology Domain is based on several indicators based on the level/weight of their influence in sequence, namely destructive and illegal fishing, modification of fishing gear and fishing aids, fishery capacity and fishing effort, selectivity of fishing, suitability of the function and size of the vessel with legal documents, and crew certification.

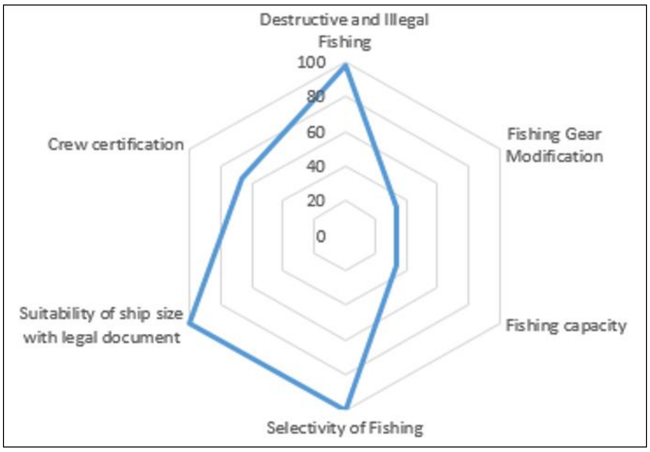

Fig 2: Chart of composite value for fishing technology domain in EAFM

Destructive and Illegal Fishing

This indicator assessment aims to determine the impact of using fishing gear on the sustainability of fish resources. Destructive fishing and/or illegal fishing include the use of hazardous materials and/or tools such as fish bombs, cyanide poison, potassium, and electricity; and the use of fishing gear that is not in accordance with the provisions of applicable regulations, such as the use of prohibited fishing gear or exploitation of protected marine habitats.

Fishing Gear Modification

The assessment of this indicator is almost the same as the assessment of the Yuwana Fish Proportion indicator. This is because to find out whether in a waters there are modifications to fishing gear or fishing aids that can threaten the sustainability of fish resources is to look at the size of the target fish caught by local fishermen. If it turns out that the length or weight of the target fish is dominated by fish that have not yet reached adult size, it is estimated that there is a modification of fishing gear or fishing aids that are not in accordance with regulations. This modification process is usually carried out subtly and clandestinely to outsmart the officers, such as trawls that are prohibited from being used and then resized to a slightly smaller size and given a different name, even though the basic function and shape are relatively the same.

Fishing Capacity

The definitions for indicators of fishery capacity and fishing effort have not been clearly defined by FAO. However, based on the (National Working Group on EAFM, 2014) [12], fishery capacity is defined as the maximum amount of fish catch that can be produced in a certain period of time (years) by a fleet of vessels when fully operated. Meanwhile, fishing effort is the amount of time spent catching fish or in short, measured in trips or trips. This indicator assessment aims to determine the presence of excess fishing capacity in an area. The determination of the scale of this indicator is to calculate the ratio between the previous year's fishery capacity and the last year's fishery capacity. Fishery capacity is obtained by calculating the total multiplication between the number of ships, the number of trips, and the total production in each year.

Selectivity of Fishing

The selectivity of fishing is closely related to the use of environmentally friendly fishing gear, so that it is known its effect on the sustainability of fish resources. The more use of fishing gear that is not environmentally friendly or prohibited from use, the fishing activity becomes less selective. The results show that the use of fishing gear by fishermen is in accordance with regulations and environmentally friendly.

Suitability of Ship Size with Legal Document

The measurement of this indicator aims to determine the impact of fishing pressure on the sustainability of fish resources. The incompatibility of the function and size of the ship with legal documents can be categorized as an act of illegal fishing. This certainly can threaten the sustainability of fish resources because neither the fleet nor the fishing activities carried out are properly recorded in accordance with applicable regulations. A further impact is that the information and data generated in general can be biased and invalid. In accordance with the partnership cycle in sustainable fisheries management according to (Baker & Anderson, 2015) [4], the compliance of these fishermen is one of the important aspects that can ensure the sustainability of the cycle. Fishermen who do not comply with regulations will hinder or break the partnership cycle which in turn will have an impact on sustainability in fisheries management.

Crew Certification

This indicator assessment aims to identify whether fishing activities have been carried out responsibly or not by fishing vessel crews. Crew certification is related to the skill level of the crew in carrying out their activities on the ship. As applies to other types of professions, assurance of skills in the form of ownership of a crew's certificate is also very important and has more value as a crew member. Ownership of certificates by fishermen in addition to guaranteeing the competence and skills of fishermen in carrying out fishing activities also minimizes the level of work accidents due to fishermen who have not been certified as seafarers, which is one of the professions with a high level of accident vulnerability. In addition, based on the (National Working Group on EAFM, 2014) [12] ownership of a crew's certificate is also useful to ensure that the fishing process is carried out by fishermen who are familiar with responsible fisheries, so that it does not endanger sustainability of fish resources.

4. Conclusion

Based on the results of the assessment of the fish resource domain, there are two indicators that have low sustainability values, namely the Catch per Unit Effort (CpUE) and the proportion of juvenile fish with less category. While in the domain of fishing technology, indicators that have less sustainability value are modification of fishing gear and fishery capacity with less category too. The low values of these four indicators indicate that there is a tendency for overfishing around these waters so that control efforts are needed to be more sustainable.

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