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Management Status of Tuna Longline Fisheries Based on Cilacap Ocean Fishing Port: an Ecosystem Approach

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Abstract— The tuna fishery in the Indian Ocean faces increasing ecological pressure due to overfishing, the capture of juvenile tuna, and bycatch of endangered, threatened, and protected (ETP) species, threatening the sustainability of tuna resources in Fisheries Management Area 573 (FMA 573). This study aimed to evaluate the management status of the tuna longline fishery based at Cilacap Ocean Fishing Port (PPS Cilacap) using the Ecosystem Approach to Fisheries Management (EAFM). A descriptive approach combined with a composite index assessment was applied across six EAFM domains: fishery resources, aquatic habitats and ecosystems, economy, social, fishing techniques, and institutional. Data were obtained through field observations, structured interviews, questionnaires, and document reviews. The results showed that the fishery resources (59.71), aquatic habitats and ecosystems (51.67), and economic (51.52) domains were classified as 'moderate', while the institutional domain (78.94) was 'good', and the social (87.90) and fishing techniques (81.38) domains were 'very good'. Overall, the tuna longline fishery achieved a composite score of 68.52, indicating a 'good' management status. Nevertheless, improvements are required to strengthen fishery resource management, habitat conservation, bycatch mitigation, and monitoring systems. These findings provide a scientific basis for improving ecosystem-based fisheries management and supporting the long-term sustainability of tuna longline fisheries in FMA 573.

Keywords— EAFM, FMA 573, Longline, Sustainability, Tuna fisheries

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I. INTRODUCTION

Indonesia is one of the world's largest tuna producing countries and plays a strategic role in supporting the global tuna supply, ensuring food security, generating employment, and contributing to national foreign exchange earnings. The southern waters of Java, which form part of the Fisheries Management Area of the Republic of Indonesia (WPPNRI) 573, represent one of the principal fishing grounds for highly migratory tuna species, including yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*), and albacore (*Thunnus alalunga*). Cilacap Ocean Fishing Port (PPS Cilacap) serves as one of the primary operational bases for the tuna longline fishery exploiting these resources in the eastern Indian Ocean. Despite its strategic importance, tuna fisheries management at PPS Cilacap continues to face several challenges. These include indications of increasing fishing pressure on bigeye tuna, a high proportion of individuals being harvested before reaching their size at first sexual maturity, and the continued occurrence of bycatch, particularly sharks, rays, and sea turtles, in the tuna longline fleet based at PPS Cilacap [35]. To mitigate bycatch, several management measures have been introduced. Among these, the use of circle hooks has been reported to reduce shark catch rates by 17.1–27.5% compared with J-hooks without compromising catches of bigeye tuna, the target species [5].

The management of transboundary tuna resources in the Indian Ocean continues to face significant challenges due to intense competition for resource utilization and the need to balance conservation objectives with economic interests [2]. Advances in fishing technology have improved operational efficiency and altered patterns of tuna exploitation, potentially increasing fishing pressure in the absence of adaptive management policies [33]. In Indonesia, [13] reported that the bigeye tuna longline fishery in the eastern Indian Ocean exhibited fluctuations in catch per unit effort (CPUE), with an overall declining trend during certain periods, accompanied by the dominance of smaller-sized individuals in the catch. These patterns suggest increasing pressure on the stock due to intensive fishing activities and the potential depletion of mature individuals in the population. Such findings highlight the importance of continuous stock monitoring and the implementation of adaptive management strategies to ensure the long-term sustainability of tuna resources. Furthermore, the reported vulnerability of yellowfin tuna stocks [14] further underscores the need to adopt a precautionary, science-based approach to fisheries management.

The Ecosystem Approach to Fisheries Management (EAFM) has been increasingly adopted as a comprehensive fisheries management framework, as it

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integrates ecological, economic, social, fishing technology, and institutional dimensions into the decision-making process. A growing body of research highlights the importance of EAFM in promoting sustainable fisheries management through the integration of ecological, social, and economic considerations. [26] emphasized that EAFM implementation can strengthen fisheries governance, although its application continues to face institutional and technical challenges. Similarly, [6] demonstrated that the operational use of ecosystem models can enhance the effectiveness of decision-making within an ecosystem-based fisheries management framework.

Comprehensive information on the management status of the tuna longline fishery based at PPS Cilacap remains limited, particularly from an ecosystem-based management perspective using EAFM. This framework integrates six domains: fish resources, habitat and ecosystems, fishing practices, economic, social, and institutional dimensions. Previous studies have primarily focused on stock assessment, biological characteristics, catch composition, fishing operations, or specific management aspects of tuna fisheries, without incorporating all six EAFM domains into a single comprehensive assessment framework. Such information is essential for supporting sustainable tuna fisheries management in FMA 573, particularly in response to increasing fishing pressure and changing ecosystem conditions that require adaptive and integrated management strategies. Therefore, this study addresses this knowledge gap by comprehensively evaluating the management status of the tuna longline fishery based on the six EAFM domains. In addition, indicator-based management recommendations were developed for each domain to support the implementation of adaptive, ecosystem-based fisheries management in FMA 573.

II. METHOD

A. Studi Site

This study was conducted from January to May 2026 at the Cilacap Oceanic Fisheries Port (PPS Cilacap), Central Java Province, Indonesia (Figure 1). PPS Cilacap was selected as the study site because it is one of the main landing ports for tuna fisheries operating in the eastern Indian Ocean. The port supports longline fishing activities targeting economically important tuna species, particularly yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*), and albacore (*Thunnus alalunga*). As a key landing base for tuna longline fisheries, PPS Cilacap plays an important role in fish landing, fisheries monitoring, and management. Moreover, the increasing pressure on tuna resources and the declining trend in catch per unit effort (CPUE) in recent years highlight the need to evaluate the sustainability of the tuna longline fishery in this area.

B. Data Collection

This study employed descriptive analysis and a scoring-based assessment to evaluate the sustainability status of the tuna longline fishery based at PPS Cilacap using EAFM. Both primary and secondary data were collected. Primary data were obtained through field observations, structured interviews, questionnaire surveys, and direct measurements of 420 tuna specimens, comprising 140 bigeye tuna, 140 yellowfin tuna and 140 albacore. Fork length (FL) was measured for each specimen to assess length-frequency structure and evaluate the condition of fish resources. The respondents included vessel captains, vessel owners, port managers, and other stakeholders involved in the tuna longline fishery. Secondary data consisted of annual fisheries statistics obtained from PPS Cilacap, including a five-year time series of catch data covering the period 2020–2024. Data collection was supported by the use of a fish measuring board for fork length measurements, a digital camera for field documentation, and standard recording sheets for data collection. All data were processed using Microsoft Excel to calculate the EAFM composite index, while ArcGIS software was used to visualize the fishing grounds.

C. Data Analysis

The EAFM assessment was based on six domains: fish resources, habitat and aquatic ecosystems, fishing practices, social, economic, and governance. The sustainability status of the tuna longline fishery based at PPS Cilacap was evaluated using a scoring system with a three-point scale, representing poor, moderate, and good conditions. EAFM aspect value classifier with score value limits. The score value limits in this study are in Table 1.

The next step is to calculate the index value for each indicator based on its score and weight. Weights are assigned according to the significance or level of importance of each indicator in the assessment. The equation used to calculate the index value of an indicator based on [23] is as follows:

$$\text{Index value} = \text{score} \times 100 \times \text{weight} \quad (1)$$

Where:
Index value = The index value of the i-th indicator
Score = Score of the i-th indicator
Weight = Weight of the i-th indicator

After all the indicators are assessed, the next step is to calculate the total score of each indicator within a dimension, which is then analyzed using a simple composite method based on the arithmetic mean. The results of this calculation are then visualized in the form of a flag model to show the level of sustainability for each aspect. The determination of the composite value for each EAFM aspect refers to the following [23] formula:

$$NK_i = \frac{C_{at-i}}{C_{at-imax}} x100 \quad (2)$$

Where:
NK_i = Composite score on the i-th aspect
C_{at-i} = The total index value of all indicators in the i-th aspect
$C_{at-imax}$ = The maximum value in the i-th aspect

The Cat-imax score is obtained when all indicators in an aspect are at the highest score, which is 3. If all

attributes reach the maximum value, the aspect is considered to be in good condition [23]. The final composite score for each aspect is then displayed in the flag model with five assessment categories based on the score range obtained (Table 2).

Assessment of catch per unit effort (CPUE) is carried out to understand trends in changes in capture productivity as an indicator of fish stock abundance over time. A declining CPUE trend may indicate a decrease in fish stocks or increased exploitation pressure leading to overfishing conditions. CPUE values according to Hall (1999) are used as a proxy for stock abundance and are calculated using the equation:

$$CPUE = \frac{C}{F} \qquad (3)$$

Where:
C = Total catch (kg)
F = Effort (*trip*)

III. RESULTS AND DISCUSSION

A. Longline tuna fishery based at PPS Cilacap

Cilacap Ocean Fishing Port (PPS Cilacap), located at 7°44′00″ S and 109°00′00″ E, is one of the largest fishing ports in Cilacap Regency and serves as a major hub for capture fisheries in the southern waters of Java. In addition to functioning as a fish landing site, the port also plays an important role in fish distribution, processing, and fisheries data collection. According to the 2024 fisheries statistics, 97 longline vessels were registered at PPS Cilacap. These vessels primarily target large pelagic tuna species, including yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*), and albacore (*Thunnus alalunga*), while sharks constitute the main bycatch.

Field observations revealed that tuna landings at PPS Cilacap are currently dominated by handline vessels rather than longline vessels. This shift is likely driven by economic considerations, as longline operations involve substantially higher operational costs, particularly for fuel, bait, and longer fishing trips. [3] similarly reported that handline fisheries at PPS Cilacap are more economically viable because of their lower operating costs, whereas [27] identified fuel as the largest operational expense in the tuna longline fishery within FMA 573.

The operational characteristics of the tuna longline fishery at PPS Cilacap reflect the technical capacity required to exploit offshore tuna resources. The fleet consists of vessels ranging from approximately 10 to 200 GT, with the majority belonging to the 30–100 GT class and equipped with refrigerated fish holds to maintain tuna quality during fishing trips lasting 10–60 days. Vessel size, onboard cold-storage facilities, and fishing gear configuration together determine fishing range, trip duration, catch handling, and overall operational efficiency. Larger vessels are able to operate farther offshore while maintaining fish quality throughout extended voyages, thereby supporting higher harvesting capacity. These findings are consistent with [18], who reported that vessel size strongly influences the productivity of tuna longline fisheries, while [31] emphasized the importance of onboard cold storage for preserving the quality of export-grade tuna.

The longline gear consists of a mainline, branch lines, hooks, floats, sinkers, and flag buoys. Field observations showed that each longline section is approximately 30 m long and carries around 60 hooks, with up to 1,500 hooks deployed during a single fishing operation. Fishing is conducted through two daily setting and hauling cycles, with hook soaking times generally ranging from 4 to 8 hours but occasionally exceeding 10 hours. While these operational practices are intended to maximize tuna catches by adapting to tuna behavior and environmental conditions, prolonged soaking times may also increase interactions with non-target species, particularly sharks, thereby increasing the risk of bycatch [13] [19].

After returning to port, longline vessels typically land their catches twice a week, on Mondays and Fridays. Unloading activities generally take place between 03:00 AM and 12:00 PM and last approximately 4–8 hours, depending on the volume of fish landed. Most tuna are stored frozen onboard to preserve quality during the fishing trip, although premium-grade fish are occasionally landed fresh and individually packaged. The catch is subsequently washed, weighed, sorted, and graded before being distributed to processing companies, export markets, or local traders, depending on product quality.

Fishing operations remain highly dependent on fishers' experience in selecting fishing grounds, whereas the use of supporting technologies is still relatively limited. Field interviews also revealed a gradual shift from longline to handline fishing, largely driven by increasing operational costs, particularly fuel expenses. Although handline fishing is considered more cost-efficient, longline remains essential for large-scale tuna fisheries because of its wider fishing range and greater production capacity [13].

TABLE 1.
SCORE LIMITS FOR EAFM INDICATORS

Indicator score	Description	Color
1.00 – 1.50	Low	
1.51 – 2.50	Medium	
2.51 – 3.00	High	

Source: NWG EAFM (2014)

TABLE 2.
COMPOSITE VALUE LIMIT OF THE EAFM ASPECT

Composite score	Flag model	Description
1 – 20		Bad
21 – 40		Not Good
41 – 60		Average
61 – 80		Good
81 – 100		Very Good

Source: NWG EAFM (2014)

B. Management status of tuna longline fishery at PPS Cilacap based on EAFM indicators

1) Fishery resources domain

The fish resources domain achieved a composite score of 59.71, placing it in the "moderate" category. Among the assessed indicators, trends in catch per unit effort (CPUE), fish size, and the proportion of juvenile fish were all classified as moderate, whereas catch composition was rated as good. In contrast, the range collapse and Endangered, Threatened, and Protected (ETP) species indicators received low ratings. The tuna longline fishery at PPS Cilacap is dominated by large pelagic tuna species, primarily bigeye tuna (*Thunnus obesus*), yellowfin tuna (*Thunnus albacares*), and albacore (*Thunnus alalunga*), while pelagic sharks constitute the predominant bycatch group.

The catch composition during 2020–2024 was dominated by bigeye tuna, accounting for 5,155,689 kg (56%)**,** followed by yellowfin tuna with 3,200,830 kg (35%) and albacore with 792,634 kg (9%) (Figure 1). The predominance of bigeye tuna reflects its suitability to the deeper oceanic habitats typically targeted by longline fisheries. The substantial contribution of yellowfin tuna is also consistent with the environmental characteristics of the southern Java waters, where sea surface temperature, chlorophyll-*a*, ocean currents, and seasonal upwelling strongly influence tuna distribution and availability [37]. In contrast, the lower proportion of albacore is likely related to its preference for cooler subtropical waters, where its distribution is shaped by temperature, salinity, dissolved oxygen, and seasonal oceanographic variability [21].

Besides the target tuna species, the fishery also recorded substantial shark bycatch, dominated by blue shark (*Prionace glauca*) (222,574 kg), followed by silky shark (*Carcharhinus falciformis*) (77,893 kg), bigeye thresher shark (*Alopias superciliosus*) (76,493 kg), and pelagic thresher shark (*Alopias pelagicus*) (46,447 kg) (Figure 2). Several of these species are listed in the IUCN Red List and CITES Appendix II, highlighting continued interactions between tuna longline fisheries and vulnerable pelagic shark populations. These findings emphasize the importance of strengthening bycatch mitigation measures and monitoring programs to support sustainable tuna fisheries management [11].

CPUE showed fluctuating patterns among tuna species during 2020–2024 (Figure 3). Bigeye tuna reached its highest CPUE in 2022 before declining in the following two years, while albacore exhibited a similar pattern. Yellowfin tuna showed a more gradual increase until 2023, followed by a slight decline in 2024. Overall, tuna CPUE declined by 11.7% over the five-year period. Under the EAFM framework, CPUE serves as a key indicator of changes in fishery productivity over time. Although declining CPUE does not necessarily indicate reduced stock abundance because it may also be influenced by environmental variability, fishing strategies, and shifts in fishing grounds, the observed trend nevertheless suggests increasing pressure on the fishery and highlights the need for effective management measures, including fishing effort control, fleet capacity evaluation, and continuous resource monitoring [29].

Fork length measurements further indicated differences in size structure among the three tuna species (Figure 4). Bigeye tuna (n = 140) ranged from 80–168 cm FL, with the dominant length class of 109–118 cm (24 individuals). Yellowfin tuna (n = 140) ranged from 69–148 cm FL, with most individuals falling within 99–108 cm (30 individuals). Albacore (n= 140) ranged from 68–147 cm FL, with the dominant length class of 78–87 cm (34 individuals). Based on the length at first maturity (*Lm*) (Table 3), 52.86% of bigeye tuna were above the maturity threshold, whereas 47.14% remained below it. In contrast, 54.29% of yellowfin tuna were below *Lm*, while only 45.71% had reached maturity. Albacore showed the opposite pattern, with 64.29% of individuals exceeding *Lm* and 35.71% remaining below it. Overall, 54.29% of the tuna sampled were classified as catchable-sized fish, whereas 45.71% had not yet reached the size at first maturity.

The relatively high proportion of fish below *Lm*, particularly for yellowfin and bigeye tuna, indicates that the fishery continues to harvest a considerable number of immature individuals. Persistent removal of immature fish can reduce reproductive potential and increase the risk of growth overfishing [9]. These findings underscore the importance of routinely monitoring catch size composition and implementing minimum legal catch-size regulations as part of ecosystem-based fisheries management. They also reinforce the value of incorporating catch size characteristics into fishing gear evaluation and management, as recommended by [30].

Fishing activity was concentrated between 107°–110° E and 7°–10° S at depths of 2,000–6,000 m, consistent with the oceanic habitat of large pelagic tuna (Figure 5). Fishing grounds shifted farther southwest into deeper waters **(**>4,248 m) during January–March but became more concentrated south of Java from July to November, reflecting seasonal changes associated with the southeast monsoon. Interviews with fishers also indicated that fishing grounds have gradually moved farther offshore in recent years, likely duet o declining carches in traditional fishing areas.

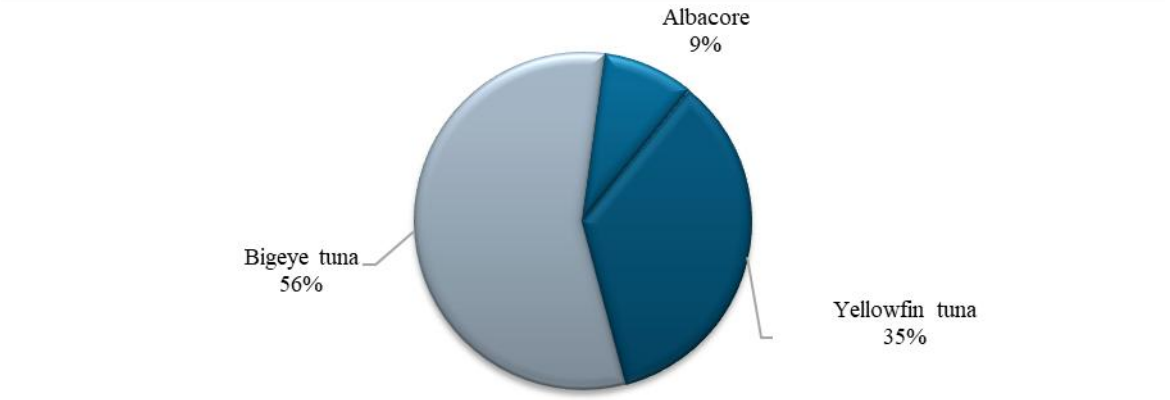


Figure. 1. Composition of longline tuna catches landed at PPS Cilacap

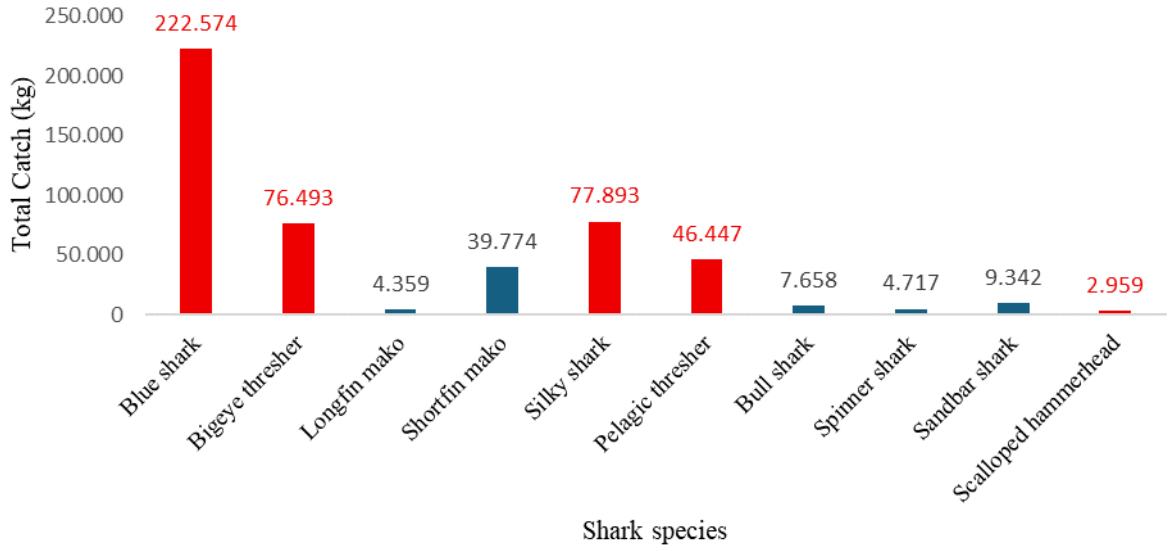
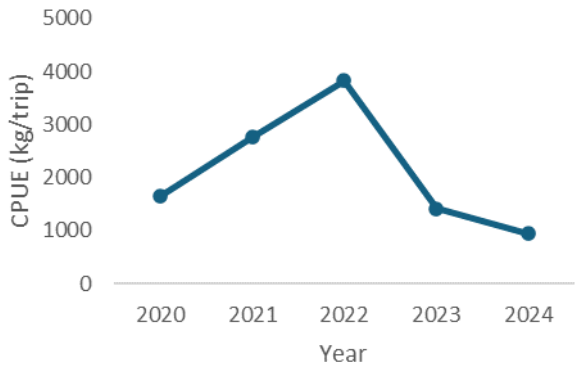
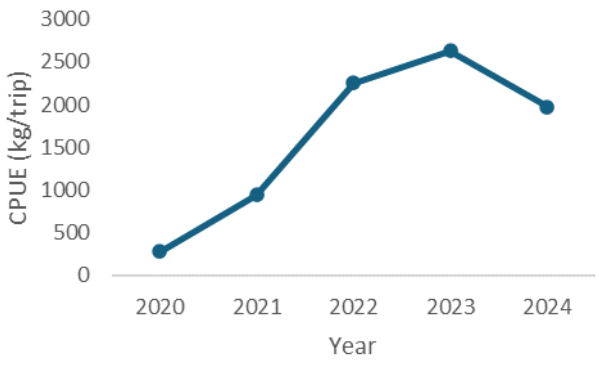


Figure. 2. Bycatch catches of shark species landed at PPS Cilacap

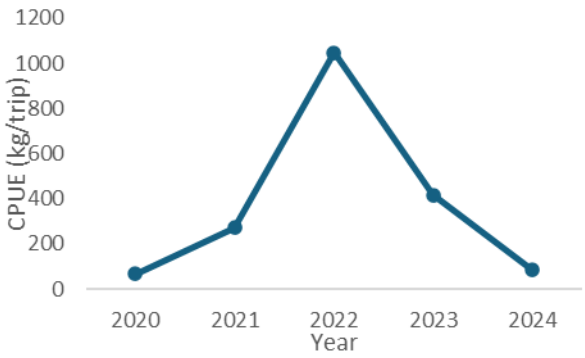
Description: Shark species highlighted in red indicate species with high conservation concern according to the IUCN Red List and listed under CITES Appendix II.



(a)

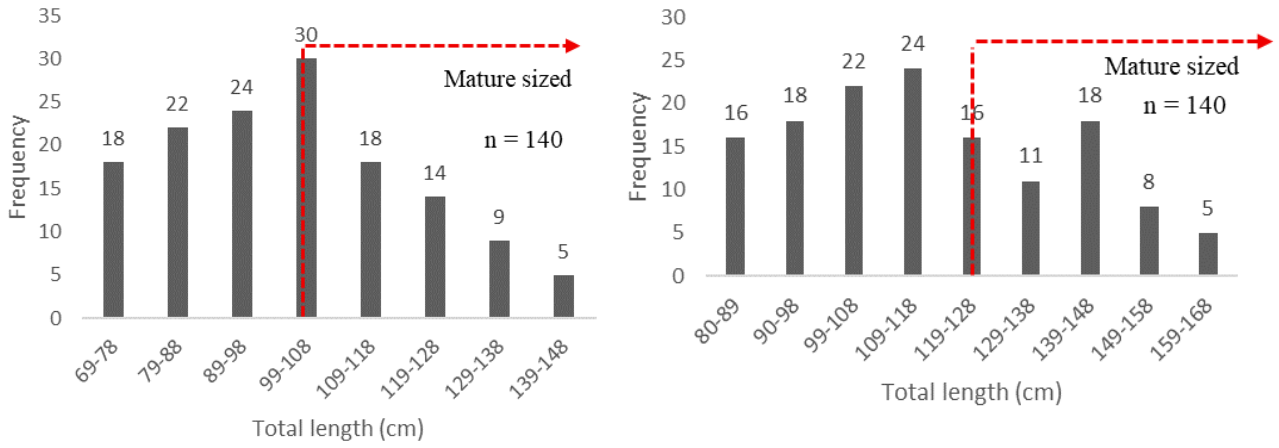


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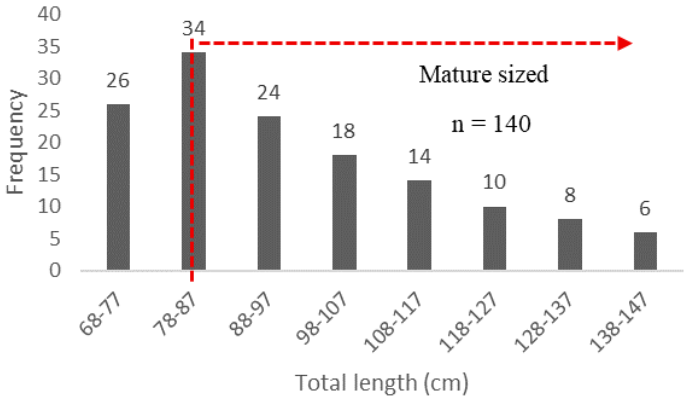


(c)

Figure. 3. CPUE trends of (a) bigeye tuna (b) yellowfin tuna (c) albacore tuna landed at PPS Cilacap



(a) (b)



(c)

Figure. 4. Frequency distribution of yellowfin tuna (a), bigeye tuna (b), and albacore tuna (c) lengths landed at PPS Cilacap

Description:
N = Number of individuals measured for each species.
Red line = Length at first sexual maturity (Lm) for each species.

TABLE 3.
COMPOSITE VALUE LIMIT OF THE EAFM ASPECT

Spesies of fish	Lm (cm)	Area	Sourch	Lm in this study (cm)
Bigeye tuna (*Thunnus obesus)*	102 125	Western Indian Ocean India Ocean	Lin *et al.* (2020) IOTC (2021)	118
Yellowfin tuna (*Thunnus albacares)*	100 105	Indian Ocean	Ghofar *et al.* (2021)	107
Albacore (*Thunnus alalunga)*	80-90	Indian Ocean	Mondal dan Lee (2023)	94.14

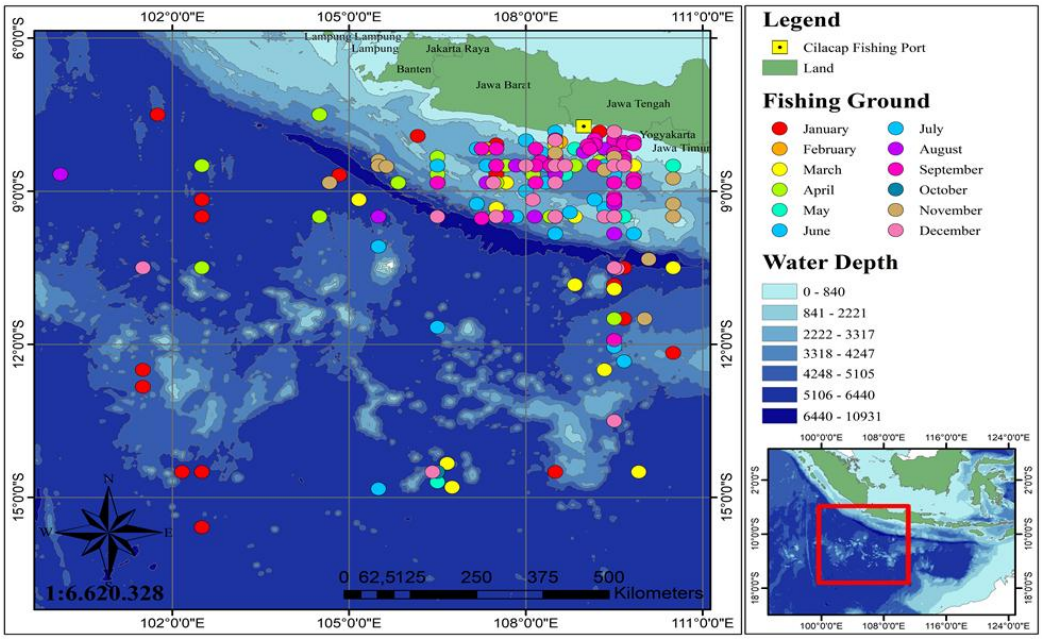


Figure. 5. Fishing areas of the longline tuna (January-December 2024) based at PPS Cilacap

2) *Habitat and aquatic ecosystem domain*

The habitat and aquatic ecosystem domain obtained a "moderate" score 51.67, indicating that the habitat conditions supporting tuna fisheries in WPPNRI 573 are relatively adequate but still require improvement. The habitat and aquatic ecosystem domain achieved a composite score of 51.67, placing it in the moderatecategory. Seagrass, mangrove, and coral reef ecosystem indicators were each rated as moderate, whereas the unique/special habitat indicator received a low score. Interview results further revealed that most fishers and port authorities have limited knowledge of critical tuna habitats, including spawning grounds, nursery areas, aggregation sites, and migration routes, with fishing grounds still largely determined by operational experience, seasonal patterns, and the presence of fish schools.

These findings suggest that, although habitats within FMA 573 continue to support tuna fisheries, important knowledge gaps remain regarding key tuna habitats. Seasonal upwelling in the southern Indian Ocean off Java enhances nutrient availability, chlorophyll-a concentration, and primary productivity, creating favorable conditions for tuna distribution [21][16]. At the same time, coastal ecosystems such as seagrass beds, mangrove forests, and coral reefs contribute to maintaining ecosystem productivity, biodiversity, and ecological resilience, which indirectly support offshore fisheries [1][24]. The limited information on critical tuna habitats highlights the need for further ecological research to strengthen ecosystem-based fisheries management in FMA 573.

3) Economic domain

The economic domain received a composite score of 51.52, indicating a moderate level of performance. Asset ownership was rated as moderate, whereas household income and the savings ratio received low scores, suggesting that the economic benefits of the fishery have yet to be distributed evenly. Although tuna prices increased during the second half of 2024, reaching IDR26,583/kg for bigeye tuna, IDR 31,500/kg for yellowfin tuna, and IDR 30,000/kg for albacore, fishers' income remained closely tied to catch volume and the profit-sharing system (Figure 6)

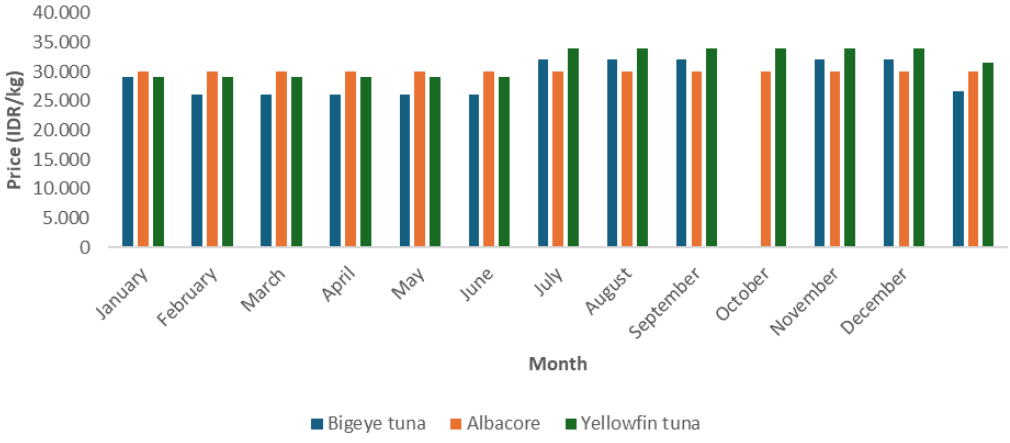


Figure. 5. Average price of tuna landed at PPS Cilacap (Januari to December 2024)

According to field interviews, vessel owners earned an average of IDR 92,000,000 per trip, while captains, chief engineers, and crew members received approximately IDR 1,200,000, IDR 750,000, and IDR 450,000 per trip, respectively. With average monthly expenses of around IDR 700,000, many crew members struggled to meet their basic living costs. Longline operations also required an average of IDR 64,660,000 per trip, with fuel accounting for IDR 54,400,000, making it by far the largest operating expense.

These results highlight the economic vulnerability of the fishery. Income fluctuates with catch and market prices, while high operating costs further reduce profitability, particularly for crew members. Similar challenges have been reported in other Indonesian fisheries, where dependence on seasonal catches, limited access to capital, and rising production costs constrain household economic resilience [28][34]. Improving cost efficiency, strengthening institutional support, and creating a fairer distribution of economic benefits would help enhance the long-term sustainability of the tuna longline fishery [7][36].

4) Social domain

The social domain achieved the highest composite score among all EAFM domains (87.90), indicating that social conditions generally support sustainable tuna fisheries management at PPS Cilacap. Strong stakeholder participation reflects effective collaboration among fishers, vessel owners, port authorities, government agencies, and fisheries inspectors in activities such as catch monitoring, logbook reporting, and regulatory compliance. Similar findings have been reported by [32] and [25], who emphasized that active stakeholder engagement strengthens co-management, improves compliance, and enhances the effectiveness of fisheries governance.

Conflicts among fishers were reported to be infrequent, occurring fewer than twice per year and mainly involving operational issues such as unloading schedules, limited berthing space, and fishing gear damage. The relatively low level of conflict is likely related to the wide offshore fishing grounds exploited by the longline fleet, which reduce competition over fishing areas [4].

Although local ecological knowledge remains an important basis for identifying fishing seasons, oceanographic conditions, and potential fishing grounds, its integration into ecosystem-based fisheries management is still limited. Fishers continue to rely primarily on accumulated experience and information shared within the fishing community [16], while knowledge of habitat conservation and bycatch mitigation remains relatively limited. Strengthening outreach and capacity-building programs that combine scientific knowledge with local ecological knowledge would further support the implementation of ecosystem-based fisheries management [8].

5) Fishing techniques domain

The fishing technique domain achieved a composite score of 81.38, placing it in the "very good" category. The highest scores were obtained for indicators related to destructive and illegal fishing practices, fishing capacity and effort, and the consistency between vessel characteristics and legal documentation, while fishing gear modification and gear selectivity received moderate scores. Crew certification recorded the lowest score, indicating that this aspect remains a key area for improvement.

Overall, the results suggest that tuna longline operations at PPS Cilacap are generally consistent with the principles of responsible fishing. No destructive or illegal fishing practices were observed during the study, and longline gear remains relatively selective for large pelagic tuna while causing minimal physical disturbance to marine habitats because it does not come into contact with the seabed [11]. In addition, the recent decline in the number of active longline vessels, together with the gradual shift of some fishers to handline fisheries, may have contributed to more controlled fishing effort and reduced fishing pressure [23].

Nevertheless, several technical aspects still require attention. The continued occurrence of shark bycatch indicates that interactions with non-target species remain an important management issue, highlighting the need to improve gear selectivity and strengthen the adoption of bycatch mitigation measures. Furthermore, the low level of crew certification suggests that many fishers still rely primarily on practical experience rather than formal training. Expanding certification and technical training programs would improve crew competence, enhance onboard safety, and further support the implementation of responsible fishing practices.

6) Institutional domain

The institutional domain achieved a composite score of 78.94, placing it in the "good" category. This result suggests that the institutional framework supporting tuna longline fisheries management at PPS Cilacap is generally well established. Fisheries management is supported by national regulations on vessel licensing, fishing gear, catch reporting, and vessel monitoring through the Vessel Monitoring System (VMS), while fishing activities also comply with conservation and management measures established by the Indian Ocean Tuna Commission (IOTC), particularly those related to bycatch mitigation and the protection of endangered, threatened, and protected (ETP) species. Strong institutional support and policy coordination are widely recognized as essential components of ecosystem-based fisheries management [26].

Despite this positive performance, several governance challenges remain. Limited human resources, the vast offshore fishing area, and constraints in monitoring and enforcement continue to affect the implementation of fisheries regulations. In addition, many fishers still rely primarily on practical experience rather than ecosystem-based management approaches. Strengthening interagency coordination, improving monitoring systems, and enhancing fishers' capacity will therefore be important to support more effective and adaptive tuna fisheries management [6].

Overall, the EAFM assessment indicates that the tuna longline fishery at PPS Cilacap is generally managed at a good level (Table 4). The social and fishing technique domains showed the strongest performance, followed by the institutional domain, whereas the fishery resources, habitat and aquatic ecosystems, and economic domains remained in the moderate category.

TABLE 4.
OVERALL EAFM ASSESSMENT OF THE LONGLINE TUNA FISHERY AT PPS CILACAP

Indicator	Score	Weight	Index value
Fish Resource Domain			
Standardized Catch Per Unit Effort (CPUE)	2	40	6057
Fish size	2	20	3829
Proportion of juvenile fish caught	2	15	3600
Catch composition	3	10	2829
Range collapse	1	10	543
ETP species (Endangered, Threatened, Protected)	1	5	1057
Composite value	59,71		
Aquatic Habitats and Ecosystems Domain			
Status of seagrass ecosystem	2	25	5000
Status of mangrove ecosystem	2	10	2000
Status of coral reef ecosystem	2	20	4000
Unique/special habitats	1	45	4500
Composite value	51,67		
Economic Domain			
Asset ownership	2	45	8871
Household fisheries income (RTP)	1	30	3514
Savings ratio	1	25	3071
Composite value	51,52		
Social Domain			
Stakeholder participation	3	40	10514
Fishers conflicts	3	35	10000
Community local knowledge	2	25	5857
Composite value	87,90		
Fishing Techniques Domain			
Destructive and illegal fishing methods	3	30	9000
Fishing gear and fishing aids	2	25	7500
Fisheries capacity and fishing efforts	3	15	4500
Catch selectivity	3	15	4500
Suitability of vessel function and size with documents	3	10	3000
Crew certificates	1	5	1500
Composite value	81,38		
Institutional Domain			
Level of compliance with responsible fisheries principles	3	26	7800
Completeness of the rules in fisheries management	2	25	7500
Decision-making mechanisms	2	18	5400
Fisheries management plan	2	15	4500
Level of synergy in institutional fisheries management policies	3	11	3300
Stakeholder capacity	3	5	1500
Composite value	78,94		

C. Management measures for a sustainable tuna longline fishery

The development of management action options is carried out based on the results of the assessment of the six EAFM domains, which indicate that each domain has different levels of improvement priority. The management strategies developed are aimed at enhancing sustainability through the integrated strengthening of aspects of fish resources, habitat, fishing techniques, economy, social, and institutional elements (Table 5).

TABLE 5.
MANAGEMENT MEASURES BASED ON EAFM INDICTAORS

Indikator	*Baseline*	*Reference point*	Management measures
1) Fish Resource Domain			
CPUE Trends	2 CPUE has decreased slightly (<25% per year)	3 CPUE is stable or increasing	• Limiting fishing efforts according to the carrying capacity of fishery resources.
Fish size	2 Trend of relatively stable size	3 The trend is getting bigger in size	• Strictly monitoring fishing activities regarding bycatch and minimum legal size.
Proportion of juveniles caught	2 A lot (30-60%)	3 few (<30%)	• Regulating fishing zones and seasons to protect spawning areas and nursery grounds. • Enhancing understanding among key stakeholders through socialization and outreach related to ETP species.
Catch composition	3 a bigger target proportion (>31% of the total volume)	3 a bigger target proportion (>31% of the total volume)	
Range collapse	1 The capture location is getting farther	2 The capture location is relatively fixed	
ETP species	1 ETP individuals who were caught but not released	2 If caught, it must be let go	
2) Aquatic Habitats and Ecosystems Domain			
Seagrass ecosystem status	2 Medium cover, ≥ 30 - < 60%	3 High cover, ≥ 60%	• Identification and designation of conservation areas, especially those related to habitats
Mangrove ecosystem status	2 Moderate cover, ≥50 - < 75%	3 High coverage, ≥75%	
Coral ecosystem status	2 moderate coverage, ≥25-<50%	3 high cover, ≥ 50 %	
Unique/special habitats	1 No known unique/special habitat	2 It is known that there is a unique/special habitat, but it is not well managed	
3) Fishing Techniques Domain			
Destructive and illegal fishing methods	3 Low violation frequency (<5 cases per year)	3 Low violation frequency (<5 cases per year)	• Training and certification for fishing vessel crew
Modification of API and ABPI	2 25-50% of the target species size < Lm	3 < 25% of the target species size <Lm	• Supervision of licensing and the use of selective fishing methods • Optimization of logbook entries and VMS monitoring.
Fishing capacity	3 Capacity ratio >1	3 Capacity ratio >1	
Level of catch selectivity	2 Moderate (50-75%)	3 High (<50%)	
Suitability of the ship's function and size with the documents	3 The suitability is high (<30%)	3 The suitability is high (<30%)	
Crew certificates	1 certificate ownership <50%	2 certificate ownership <50-75%	
4) **Economic Domain**			
Asset ownership	2 Fixed asset value (less than 50%)	3 Asset value has increased (by more than 50%)	• Reviewing the profit-sharing system to make it fairer and more transparent for crew members
Household income of ABK	1 <*Upah Minimum Provinsi*	2 Same as *Upah Minimum Provinsi*	• Improving access to capital and insurance for fishers
Savings ratio	1 < loan interest rate <2 times a year	2 Same as loan interest <2 times a year	• Better handling and distribution of the catch

CONTINUEDTABLE 5.
MANAGEMENT MEASURES BASED ON EAFM INDICTAORS

Indikator	*Baseline*	*Reference point*	Management measures
5) Social Domain			
Fihers conflict	100% 3 <2 times a year	100% 3 <2 times a year	as capacity building of tuna longline fishers related to responsible fishing practices, reduction of ETP bycatch, and sustainable utilization of tuna resources
Local knowledge in fisheries management	2 It exists but is not effective	3 Exists and is effective to use	
6) Institutional Domain			
Level of compliance with responsible fisheries principles	3 Formal legal violations < 2 times per year, no information on non-formal violations	3 Formal legal violations < 2 times per year, no information on non-formal violations	• Synchronization of fisheries management policies at the local level with the National RPP
Completeness of the rules	2 Regulations are available covering fisheries rules for 3-5 domains	3 Complete regulations are available to support the management of the six domains	• Increasing the frequency of patrols and supervision at landing bases • Enhancing outreach and law enforcement related to the Tuna, Skipjack, and Mackerel Tuna Fisheries Management Plan (RPP TCT).
Decision-making mechanisms	2 There is a mechanism, but it does not function effectively	3 There is a mechanism and it operates effectively	
Fisheries Management Plan	2 There is a lesson plan, but it hasn't been fully implemented yet	3 There is a lesson plan and it has been fully implemented	
Level of policy and institutional management synergy in fisheries	3 The synergy between institutions runs well and the policies mutually support each other	3 The synergy between institutions runs well and the policies mutually support each other	
Stakeholder capacity	3 Exists and is functional	3 Exists and is functional	

IV. CONCLUSION

The management status of the tuna longline fishery based at Cilacap Ocean Fishing Port (PPS Cilacap), as evaluated using the Ecosystem Approach to Fisheries Management (EAFM) framework, was classified as ‘good’, with a composite score of 68.52. The fishery resources (59.71), aquatic habitats and ecosystems (51.67), and economic (51.52) domains were categorized as ‘moderate’, suggesting persistent pressure on resource sustainability and the welfare of fishery stakeholders. Conversely, the institutional domain (78.94) is indicated 'good,' while the social domain (87.90) and the fishing technique domain (81.38) are 'very good.' These findings indicate that the management of tuna longline fisheries at PPS Cilacap is generally sustainable; however, particular attention is required for the domains of fishery resources, aquatic habitats and ecosystems, and the economy to ensure the sustainability of tuna fisheries in FMA 573. The study also provides domain-specific management priorities that can support the implementation of adaptive ecosystem-based fisheries management for the tuna longline fishery.

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