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Fisheries Management and Habitat Conservation at Kutaraja Ocean Fishing Port

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ABSTRACT

The Kutaraja Ocean Fishing Port (PPS Kutaraja) is one of the largest fish landing sites in Banda Aceh, playing a significant role in shark fisheries, particularly for thresher sharks (*Alopias pelagicus)*. This study aims to describe the thresher shark fishery at PPS Kutaraja, assess the status of its utilization, and provide recommendations for sustainable management. The research was conducted through direct observations, interviews with fishermen and fishery business operators, and secondary data analysis. The results indicate that thresher sharks are primarily caught as bycatch using purse seines and longlines. The shark trade at PPS Kutaraja involves multiple stakeholders, from fishermen and intermediaries (toke bangku) to domestic and international markets. Habitat and ecosystem assessments reveal that seagrass and coral reef ecosystems along the Aceh coast are in moderate condition, while mangrove ecosystems remain relatively well-preserved. The composite evaluation of the Ecosystem Approach to Fisheries Management (EAFM) for habitat and ecosystem aspects scored 66.67, categorized as "good." However, the lack of data on key shark habitats, such as spawning, nursery, and feeding grounds, highlights the need for further research. To ensure sustainability, ecosystem-based management strategies, including establishing conservation areas and stricter monitoring of shark fishing practices, are recommended. Implementing effective policies will support the long-term sustainability of thresher shark fisheries at PPS Kutaraja.

INTRODUCTION

Shark fisheries represent a sector of high economic value in various coastal areas of Indonesia. Sharks are utilized in multiple forms, including meat, fins, and liver oil, which have domestic and international markets. However, the overexploitation of sharks, including thresher sharks (*Alopias pelagicus*), raises concerns about the sustainability of their populations. Aceh waters, particularly the Kutaraja Ocean Fishing Port, serve as one of the primary landing sites for thresher shark catches, most of which are obtained as bycatch from

purse seine and longline fishing gear. This phenomenon indicates that, although not the primary target, thresher sharks still hold significant economic value for fishermen and fish traders.

Several previous studies have examined shark fisheries in Indonesia from biological, ecological, and management perspectives. Clarke *et al*. (2004) emphasized that shark exploitation is primarily driven by the demand for shark fins in the international market. A study by Simeon *et al*. (2020) revealed that the shark trade in Indonesia involves a complex network, including distribution to foreign markets such as Singapore and China. Meanwhile, research by Efendi *et al*. (2019) highlighted that in several regions, such as Balikpapan and Bali, shark utilization is not limited to fins but also includes processed products such as salted fish and smoked meat. However, specific studies on thresher shark fisheries at the Kutaraja Ocean Fishing Port remain scarce, particularly regarding utilization patterns, trade networks, and the ecological conditions that support shark populations in this area.

The sustainability of thresher shark resources is a significant concern in fisheries management at the Kutaraja Ocean Fishing Port. Marine ecosystems such as coral reefs, seagrass beds, and mangroves are crucial in balancing shark populations and other aquatic species. According to the Aceh Coastal and Small Islands Zoning Plan (RZWP3K) document (2018), the coastal ecosystem in Aceh varies in condition, with some areas experiencing degradation due to fishing activities and environmental changes. Therefore, further in-depth research is required to assess the status of thresher shark resource utilization and its relationship with the surrounding ecosystem.

The increasing global demand for shark products, especially fins, has intensified fishing pressure on shark populations worldwide (Worm & Branch, 2012). This demand drives both targeted shark fisheries and the retention of sharks as bycatch, contributing to the decline of many shark species. Understanding the dynamics of shark fisheries, including catch composition, trade routes, and stakeholder involvement, is crucial for developing effective conservation and management strategies (Dulvy *et al*., 2014). Furthermore, assessing the socio-economic factors influencing fishermen's behavior and dependence on shark resources is essential for designing sustainable management policies (Teh *et al*., 2015).

In the context of Indonesia, the archipelago's vast marine territory and diverse fishing practices present unique challenges for managing shark fisheries. The lack of comprehensive data on shark populations, fishing efforts, and landings hinders the implementation of science-based management measures (White *et al*., 2012). Additionally, involving multiple stakeholders, including local communities, traders, and exporters, complicates the governance of shark fisheries and requires collaborative approaches to ensure compliance with regulations (Satria *et al*., 2016). Therefore, a holistic understanding of shark fisheries' ecological, economic, and social dimensions is necessary for effective management.

Given the ecological importance of sharks as apex predators and their vulnerability to overexploitation, conservation efforts are urgently needed to ensure the long-term sustainability of shark populations in Aceh and throughout Indonesia. This requires implementing science-based management measures, such as catch quotas, size limits, and gear restrictions, as well as establishing marine protected areas to safeguard critical shark habitats (Graham *et al*., 2016). Furthermore, promoting alternative livelihoods for fishermen and raising awareness among consumers about the impacts of shark consumption are essential for reducing fishing pressure on shark populations and fostering a culture of sustainability (Vannuccini, 1999). This study aims to describe the thresher shark fishery at the Kutaraja Ocean Fishing Port and analyze the status of fishery resource utilization using the

EAFM (Ecosystem Approach to Fisheries Management) indicators, particularly habitat and aquatic ecosystems. Additionally, this study seeks to provide recommendations for more sustainable management strategies to maintain ecosystem balance while ensuring economic benefits for fishermen and fisheries business actors. Given the urgency of these issues, this study is expected to contribute to the development of shark fishery management policies at the Kutaraja Ocean Fishing Port. Furthermore, it aims to enrich the scientific literature on shark fisheries in Indonesia and provide a foundation for future research on shark conservation and sustainable resource utilization.

METHODS

Data Collection

This research was conducted through a field study from June to September 2021 at the Kutaraja Ocean Fishing Port, Banda Aceh City, Aceh Province, Indonesia. The data collected included indicators aligned with the EAFM (Ecosystem Approach to Fisheries Management) guidelines on aquatic habitat and ecosystem aspects, precisely the status of seagrass ecosystems, mangrove ecosystems, coral reef ecosystems, and unique/special habitats. Data collection methods included field surveys, structured interviews using questionnaires, and literature reviews.

Field surveys, structured interviews using questionnaires, and literature reviews are essential methods for data collection in scientific research. Field surveys involve the systematic collection of empirical data directly from natural settings, allowing researchers to observe and record real-world phenomena as they occur (Fowler, 2014; Neuman, 2014). This method is particularly important in ecological and fisheries research, where environmental conditions significantly influence outcomes. Structured interviews using questionnaires employ a standardized set of questions administered uniformly to all respondents, aiming to minimize interviewer bias and ensure the consistency and comparability of data (Bryman, 2016; Bernard, 2017). This technique is valuable for gathering quantifiable information on practices, perceptions, or behaviors across large groups. Meanwhile, literature reviews involve the systematic identification, evaluation, and synthesis of existing research related to a specific topic, providing the necessary background, identifying research gaps, and justifying the relevance of new studies (Booth *et al*., 2016; Hart, 2018). Together, these methods ensure that research findings are comprehensive, credible, and grounded in both empirical evidence and existing scholarly knowledge.

The respondents in this study comprised fishermen, boat owners, skippers, and local fisheries managers, including representatives from the Aceh Provincial Marine and Fisheries Service, the Water Police, the Marine and Fisheries Resources Supervision Agency, Panglima Laot (traditional marine authorities), non-governmental organizations (NGOs), and academics. The sample of fishermen was selected to represent 25% of the total population, with 61 respondents, including boat owners, skippers, and fishermen with knowledge of purse seine, longline, and handline fishing gear. Additionally, 15 respondents from relevant stakeholders were interviewed. Respondents were selected using a purposive sampling technique based on availability, reputation, position, experience, and knowledge related to the research problem.

Data Analysis

The data were analyzed both descriptively and quantitatively to provide an overview of the thresher shark fishery and evaluate its management status in relation to habitat and aquatic ecosystems. The analysis was conducted in two stages: first, identifying each indicator,

and second, evaluating those indicators. This study utilized the Ecosystem Approach to Fisheries Management (EAFM) assessment standard, but made modifications to several indicators and criteria to better fit the specific habitat and aquatic ecosystems being examined. These adjustments were necessary to address the unique conditions of the thresher shark fishery and the availability of data collected in the field.

Indicator Identification

The status of the seagrass ecosystem, a vital component of our marine environment, was meticulously analyzed based on coverage area, density, and seagrass species composition. Data were obtained from previous studies and interviews with relevant stakeholders, such as the Marine and Fisheries Office and the Kutaraja Ocean Fishing Port Technical Implementation Unit (UPTD Kutaraja Ocean Fishing Port). Lower seagrass coverage, density, and species diversity indicate higher pressure on this crucial ecosystem, underscoring the urgency of our conservation effort.

The status of the mangrove ecosystem was assessed based on mangrove density and coverage. If the data indicate high mangrove density and coverage, it can be concluded that the quality and quantity of the mangrove ecosystem are in good condition, and vice versa. For instance, if the data show a decline in mangrove density, it could prompt the implementation of measures to protect and restore mangrove habitats.

The status of the coral reef ecosystem was identified based on the percentage of coral cover. This data was collected through underwater surveys conducted by trained marine biologists. A higher percentage of coral cover indicates better fishery productivity and overall marine environmental health.

The status of unique/special habitats was analyzed using data on fishing location coordinates and existing management efforts. Data were collected through literature reviews and interviews with relevant stakeholders, including the Marine and Fisheries Office, the Water Police, and the Kutaraja Ocean Fishing Port Technical Implementation Unit (UPTD Kutaraja Ocean Fishing Port). If unique/special habitats remain unidentified and lack management data, this may indicate that these areas have not been optimally managed. This underscores the crucial role of each stakeholder in improving the management of these unique habitats.

Indicator Assessment

EAFM indicators were evaluated using a multi-criteria analysis (MCA) approach, which involved developing a composite index. This index was formulated using a Likert scale with ordinal values of 1, 2, and 3 ([NWG EAFM, 2014). The assessment process consisted of several stages: (1) defining the criteria for each indicator, (2) assigning scores to performance indicators using an ordinal Likert scale (1, 2, 3), (3) determining the weight of each indicator, (4) calculating the index value, and (5) deriving the composite value. As stated by (NWG EAFM, 2014), the formula applied to compute the indicator index value is as follows:

$$\text{Index value} = \text{score} \times 100 \times \text{weight}$$

The composite values' results are then displayed as a flag model in Table 1 with five criteria based on the obtained value limits ([NWG EAFM, 2014).

Table 1. Domain and Aggregate Value Score Limits

Composite Score	Flag Model	Category
1 – 20		Bad
21 – 40		Poor
41 – 60		Moderate

Composite Score	Flag Model	Category
61 – 80		Good
81 – 100		Excellent

Source: NWG EAFM (2014)

RESULTS

Based on annual data, the number of fishing vessels operating at PPS Kutaraja in 2020 was recorded at 244 units, 72 units using handline fishing gear, and 172 units using purse seines. The total number of registered crew members (ABK) was 2,928 (UPTD PPS Kutaraja, 2021). The fishing vessels that capture and land sharks at PPS Kutaraja consist of ships of varying sizes, ranging from 5 to 131 GT (Figure 1). These vessels primarily utilize purse seine and longline fishing gear as their main fishing methods (Table 2). The number of crew members on a single fishing unit varies between 20 and 40 individuals, including the captain, vice-captain, engineers, crew members, and cooks.

Meanwhile, smaller vessels typically operate with 2 to 5 crew members, consisting of a captain and crew members. According to Wulandari (2021), the number of crew members in each fishing unit depends on the vessel's gross tonnage (GT); the more significant the vessel, the more crew members are required, and vice versa. Based on direct field observations, small-scale vessels, commonly known as boat mini (or boat tep-tep), are also involved in shark fishing activities, with their catches landing at Kutaraja Ocean Fishing Port. Information obtained from local fishermen indicates that sharks are caught using handline fishing gear, which crew members use as an additional fishing method to increase their overall catch.

Figure 1. The Fishing Fleet Based at Kutaraja Ocean Fishing Port

Table 2. Number of Vessels and Fishing Gear in Ocean Fishing Ports

Vessels Size (GT)	Type of Fishing Gear (unit)	
	Handline	Purse Seine
< 5	6	-
6 – 10	51	24
11 – 20	13	21
21 – 30	1	20
31 – 50	1	44
51 – 60	-	50
61 – 100	-	9
> 100	-	4
Total	**72**	**172**

Source: UPTD PPS Kutaraja (2021)

The Kutaraja Ocean Fishing Port is one of the largest fish landing centers in Banda Aceh. Based on 2020 data, the number of fishing vessels operating at PPS Kutaraja reached 244 units, 72 using handline fishing gear and 172 using purse seines. Smaller ships (<5 GT) to medium-sized vessels (6–20 GT) predominantly use handlines, while purse seines dominate larger vessels (>20 GT). The primary catch from these fleets includes pelagic fish such as tuna, skipjack, mackerel, and scad, with sharks and rays as bycatch.

The thresher shark (*Alopias pelagicus*) is the most frequently landed shark species at PPS Kutaraja. Captured sharks are typically separated from the main catch and sold to collectors (toke bangku). Some fishermen collaborate with toke bangku in an auction system with a profit-sharing agreement. The selling price of sharks is determined based on quality and weight, with more prominent individuals commanding higher prices. Shark products are generally marketed either whole or finless, with the fins removed at the port before being sold to collectors or directly to local markets such as Penayong Market and Lambaro.

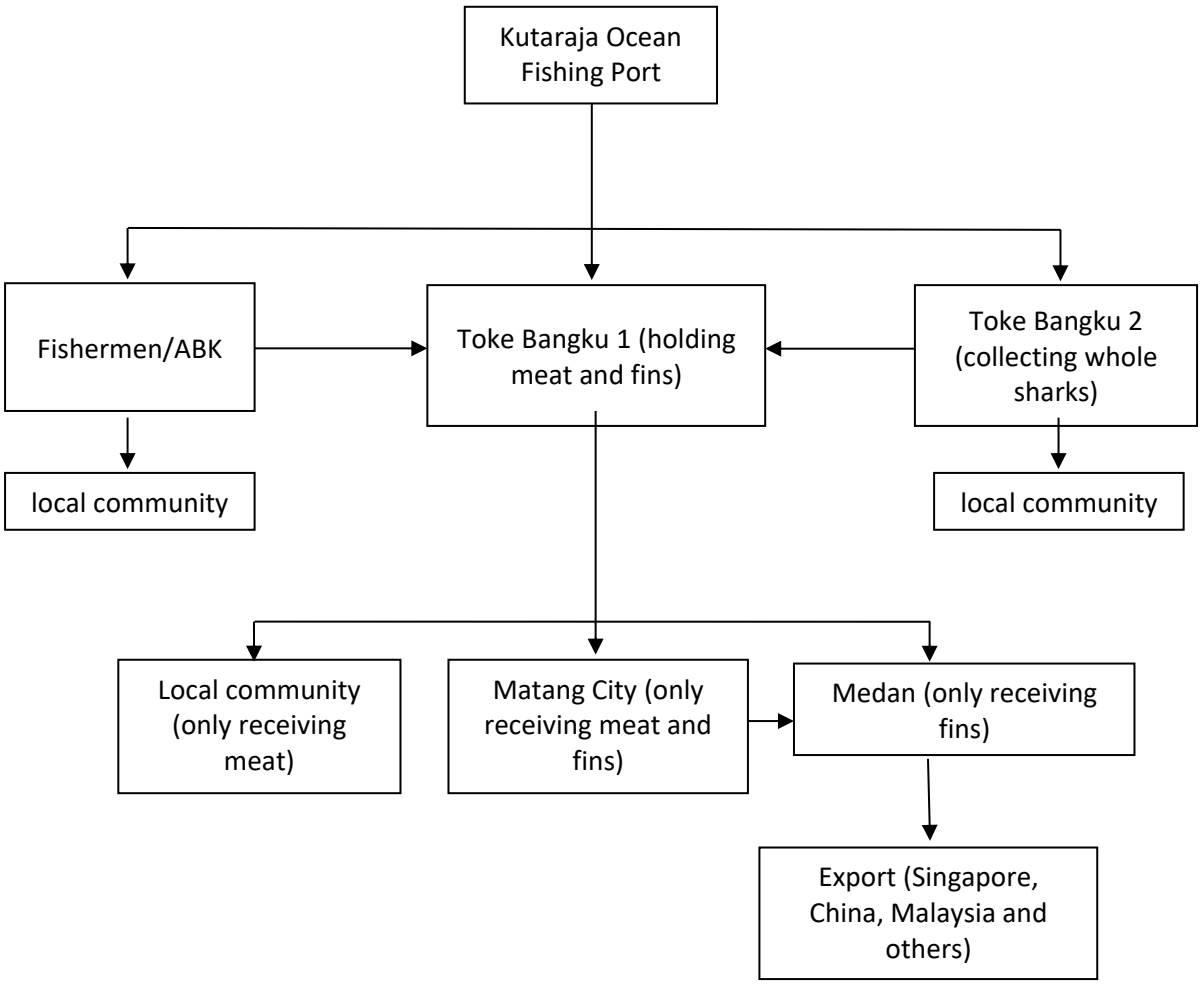


Figure 2. Shark Trade Chain Based in Kutaraja Ocean Fishing Port

Based on interviews with respondents, landed shark catches at Kutaraja Ocean Fishing Port are generally utilized locally and sold in domestic and international markets. The utilization of sharks provides economic benefits to local communities and shark traders. Sh sharks are primarily used in Aceh for their meat, fins, and oil. Each shark species sold has a relatively different price. For example, the cost of a thresher shark can reach IDR 700,000–1,200,000 per individual. Field observations indicate that their condition and size highly influence the cost of sharks. Sharks that have been cut into pieces and had their fins removed

are sold in local markets at varying prices per kilogram. The cost of cut thresher shark meat typically ranges from IDR 20,000 to 30,000 per kilogram.

These economic activities, while beneficial for local livelihoods, raise concerns about sustainability, particularly regarding habitat conditions and the overall health of marine ecosystems. The dependence on shark resources underscores the need for responsible fisheries management to ensure that shark populations remain stable. Habitat quality, including the condition of seagrass beds, mangrove forests, and coral reefs, plays a crucial role in supporting marine biodiversity, including sharks. Therefore, assessing the state of these habitats is essential in understanding the broader impact of shark fisheries on the aquatic environment.

Aceh's coastal and marine ecosystems play a crucial role in supporting marine biodiversity, including thresher shark (*Alopias pelagicus*) populations. The main habitats in Aceh consist of seagrass beds, mangroves, and coral reefs, which provide essential spawning, nursery, and feeding grounds. According to the RZWP3K (2018) document, Aceh has a seagrass ecosystem covering 44.12 hectares in the Banyak Islands, a mangrove ecosystem spanning 309.07 km², and coral reefs that are classified as 51% good, 18% moderate, and 31% degraded. The habitat and aquatic ecosystem assessment is based on two indicators: seagrass and coral reef conditions. The results of the evaluation are presented in Table 3.

Tabel 3. Habitat and Aquatic Ecosystem Composite Assessment Results

Indicator	Score	Quality	Index Value
Status of seagrass ecosystem	2	25	5000
Status of mangrove ecosystem	3	25	7500
Status of coral ecosystem	2	25	5000
Habitat is unique/special	1	25	2500
Total		100	20000
Aspect maximum value			30000
Aspect composite value			66.67

The composite value of the EAFM assessment for the habitat and aquatic ecosystem aspect resulted in a value of 66.67, categorized as "good." However, the moderate scores for seagrass and coral reef conditions indicate that management efforts still need improvement. Sustainable management practices, such as habitat restoration and stricter conservation regulations, are essential to maintain the ecological balance and ensure the long-term sustainability of thresher shark fisheries.

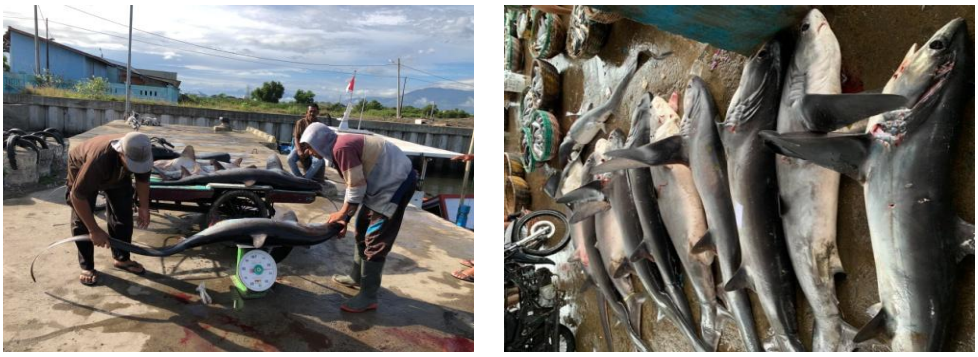
DISCUSSION

Kutaraja Ocean Fishing Port (PPS Kutaraja) is one of the largest fishing ports in Banda Aceh, located at the geographical coordinates of 5°57'63”36 N and 95°32’30" 58 E (UPTD PPS Kutaraja, 2021). According to Aceh Governor Regulation No. 27 of 2009, PPS Kutaraja operates as one of the Technical Implementation Units (UPTD) under the Aceh Marine and Fisheries Agency. PPS Kutaraja is a central landing site for fish catches, including sharks. Based on the findings of this study, sharks landed at PPS Kutaraja are primarily caught using purse seine and handline fishing fleets. Annual data from 2020 recorded 244 fishing vessels operating at PPS Kutaraja, comprising 72 handline vessels and 172 purse seine vessels. The total number of registered crew members was 2,928 (UPTD PPS Kutaraja, 2021).

Field observations show that unloading activities at PPS Kutaraja generally occur between 03:00 and 10:00 AM (WIB). The primary catches consist of pelagic fish such as tuna, skipjack, mackerel, and scad, the main target species for purse seine and handline fleets. Additionally, bycatch species such as sharks and rays also land. Sharks are considered bycatch in all fishing fleets operating at the port. Several shark species have landed at PPS Kutaraja, including the pelagic thresher shark (*Alopias pelagicus*), scalloped hammerhead (*Sphyrna lewini*), great hammerhead (*Sphyrna mokarran*), oceanic whitetip shark (*Carcharhinus longimanus*), and silky shark (*Carcharhinus falciformis*). Among these species, the pelagic thresher shark (*Alopias pelagicus*) most frequently lands at PPS Kutaraja.

Observations indicate that landed sharks are immediately removed from the vessel's hold and separated from other catch species. Fishermen sell These sharks directly to collectors (toke bangku). In some cases, fishermen engage in an auction system with toke bangku, where profits are shared based on a prior agreement. The number of auction participants involved in shark trading at PPS Kutaraja includes 14 individuals, consisting of toke bangku and fishery business operators (WCS, 2021).

The selling price of sharks at PPS Kutaraja is determined based on their quality and weight. Higher-quality sharks with larger sizes command higher prices per kilogram. Typically, sharks are weighed without their fins to meet local market demands (Figure 5a). The price per shark is negotiated between sellers and buyers. When thresher sharks are acquired by toke bangku or fishery entrepreneurs, they are arranged neatly on the floor before being auctioned to consumers (Figure 5b). Additionally, some sharks are sold directly to local markets, depending on the traders' decisions. The primary local markets that receive shark products include Penayong Market and Lambaro Market.



(a) (b)

Figure 3. (a) Weighing Activities of Thresher Sharks and (b) Catch of Thresher Sharks Landed at PPS Kutaraja

Shark catches sold to consumers can be in the form of whole sharks or sharks without fins. If consumers prefer sharks without fins, the fin-cutting process is done directly at the port (Figure 4a). Purchased sharks, whether whole or finless, are transported using local transport services, such as traditional pedicabs (becak) (Figure 4b). Subsequently, the sharks are delivered to the consumer's desired location.

(a) (b)

Figure 4. (a) Shark Finning Activites and (b) Shark Transportation

Thresher sharks (*Alopias pelagicus*) are primarily caught as bycatch using purse seines and longlines. Purse seines encircle fish schools before tightening and hauling the net aboard, equipped with rings, purse lines, and drawstrings (Genisa, 1998). After preparations, fishermen depart from the fishing base, using rumpons and lights for night fishing. Net setting occurs around rumpon from 06:00 to 08:00 WIB, followed by hauling at 08:30 WIB. Longline operations start at 05:00 or 17:00 WIB, with mainlines measuring 300–600 meters and 20–250 hooks spaced 2–3 meters apart, though some fishermen use 15–20 meter spacing. Hook sizes vary from 1 to 12 (Figure 5). Each trip lasts 2–5 days, with 4–8 settings and 1–3 hours soaking. Baits include scad (*Decapterus* spp.) and swordfish (*Xiphias gladius*). Both purse seines and longlines primarily target small and large pelagic fish, while sharks remain a frequent bycatch.

Figure 5. Longline Fishing Gear Hook

Based on interviews with fishermen, thresher sharks are most frequently caught using handlines operated on purse seine and longline vessels. Handlines used for shark fishing are personal or additional gear crew members utilize. This fishing gear comprises a spool, mainline, branch lines, hooks, swivels, and sinkers (Figure 6).

Figure 6. The Handline Fishing Gear Used by the Crew

Fishermen reported that handline hook sizes vary, and the gear is operated before or after deploying primary fishing methods such as purse seines and longlines. The settings range from 5 to 12 per trip, with a soaking time of 1–2 hours, typically around rumpon. Handlines are an additional fishing method for crew members to optimize idle time and increase earnings. Sharks caught using handlines are considered targeted catch within purse seine and longline operations. The crew privately owns these catches and stores them separately in the vessel's hold. If storage is whole, sharks may be combined with other catches. Shark catches are excluded from the profit-sharing system on vessels ranging from 20 to 131 GT, whereas on smaller vessels, they are shared among crew members or used for personal consumption. According to vessel captains, PPS Kutaraja-based fishermen primarily operate in the Indian Ocean, with key shark fishing grounds extending north to the Andaman Sea, east to the Malacca Strait, west to the Indian Ocean, and southwest to the waters around the Nias Islands (Simeon *et al*., 2020).

The shark trade chain at PPS Kutaraja is highly complex, involving multiple key actors (Figure 2). Zainudin (2011) highlighted that the trade network at the collector level is intricate, making it difficult to establish a reliable traceability system for shark origins. Additionally, the trade process involves interconnected stakeholders, including fishermen, toke bangku 1, toke bangku 2, and local consumers.

Based on the interview findings, the trade process begins when sharks land at the port. Crew members (ABK) directly offer their catches to toke bangku 1, toke bangku 2, and local buyers. Toke bangku 1 operates as a major collector, owning several fishing vessels and handling shark meat and fins. In contrast, toke bangku 2 is an intermediary, purchasing sharks for resale. Shark meat is distributed to local markets such as Lambaro, while fins are transported to Desa Matang, Bireuen, and Medan. If shark landings are low, toke bangku 1 may source from toke bangku 2, who also sells shark meat directly to local consumers, primarily for its meat.

Sharks acquired by toke bangku 1, directly from fishermen or toke bangku 2, are further distributed to Desa Matang, where specialized collectors handle meat and fins. Interviews revealed that both toke bangku 1 and collectors in Desa Matang supply shark fins to Medan, from where they are exported to international markets such as China and Singapore. According to FAO (2015), China and Singapore have historically been the world's leading producers, processors, and re-exporters of shark fin. Additionally, Spain, Indonesia, Taiwan (China), and Japan are among the central global exporters of shark fins (Dent & Clarke, 2015). However, challenges related to data reliability and the characterization of shark fin trade statistics make it difficult to accurately assess the relative contributions of each producing country (Dent & Clarke, 2015). Given these complexities, effective management strategies for thresher shark fisheries are essential to ensure ecological sustainability and prevent overexploitation.

Based on interviews, sharks landed at PPS Kutaraja are primarily utilized locally and sold in domestic and international markets, benefiting local communities and traders. In Aceh, sharks are processed for their meat, fins, and oil. Clarke (2004) noted that sharks are exploited mainly for their fins, meat, cartilage, liver oil, and skin. Shark meat is widely consumed in Aceh, with popular dishes such as salted fish, fish balls, and gulai hiu (shark curry). Many restaurants in Banda Aceh and Aceh Besar serve gulai hiu as a regional specialty (Figure 7). Fresh shark meat is sold in local markets like Penayong and Lambaro, driving increased demand. Similar

shark utilization occurs in other regions, such as Balikpapan and Bali, where processed products include smoked meat, salted fish, and dried skin (Efendi *et al*., 2019; Easteria, 2019).

Figure 7. Shark Processed Products (Shark Curry)

Besides meat, various shark parts such as fins, bones, skin, and oil are widely traded in domestic markets, particularly Medan. Simeon *et al*. (2020) reported that these products are also marketed in Surabaya and exported to international markets, including Singapore and Malaysia. Hardiningsih *et al*. (2017) identified key domestic shark product markets such as Surabaya, East Lombok, Mataram, and Bali, while international markets include Japan, China, and Singapore (Suryagalih & Darmawan, 2012). These trade activities are primarily driven by key business players who significantly contribute to the shark industry.

Shark fins are among the most valuable shark products. Based on interviews, the price of fresh thresher shark (*Alopias pelagicus*) fins at PPS Kutaraja ranges from IDR 50,000–90,000/kg, depending on fin size and species. After processing, fins are collected by toke (shark collectors) and sent to Matang before further distribution to Medan. Simeon *et al*. (2020) reported that dried shark fins are sold at significantly higher prices, ranging from IDR 200,000 to 1,250,000/kg, catering to domestic and international markets. The high value of shark fins is attributed to their culinary demand, particularly in shark fin soup, which is prized for its distinctive texture and flavor (Yusrina *et al*., 2019).

Sharks are fully utilized in various industries, with nearly all parts holding economic value. Apart from meat and fins, shark-derived products such as bones and oil are commonly used in traditional medicine. At the same time, shark skin is processed into accessories like wallets, belts, and shoes, particularly in regions outside Aceh, such as Medan. Locally, shark liver oil is applied as a traditional remedy, known for its high squalene content, which has medicinal and cosmetic applications (Maulana *et al*., 2014; Insani *et al*., 2017). This full utilization of sharks supports local livelihoods and contributes to domestic and export markets, with no part going to waste (Haque *et al*., 2018).

However, the increasing demand for shark products raises concerns about sustainability, highlighting the need for responsible fisheries management. One crucial aspect of sustainable shark fisheries is protecting and managing marine habitats. The assessment of habitat and marine ecosystem management consists of four key indicators: seagrass, mangroves, coral reefs, and unique/special habitats. Aceh's coastal ecosystems, including seagrass beds, mangrove forests, and coral reefs, are vital in supporting marine biodiversity and fishery resources. These ecosystems are documented in the 2018 RZWP3K report as essential components of Aceh's marine ecosystem.

Seagrass beds are highly productive shallow-water ecosystems (Jalaluddin *et al*., 2020). In Aceh, they are primarily found in the Banyak Islands, covering an area of 44.12 ha, as well

as smaller patches in Pulau Aceh and Simeulue (RZWP3K, 2018). Previous studies indicate that seagrass conditions vary, with some areas classified as healthy (Maulida et al., 2018) and others in moderate condition (Nasution *et al*., 2019). Seagrass growth is influenced by physical, chemical, and biological parameters (Kurniawan *et al*., 2021). Ensuring the sustainability of seagrass and other marine habitats is essential to maintaining shark populations and supporting long-term fishery productivity.

Mangrove ecosystems in Aceh cover approximately 309.07 km², with 30 identified species and an average tree density of 1,811 individuals per hectare (RZWP3K, 2018). This suggests a generally good mangrove condition. Mangroves are essential habitats for juvenile fish, crustaceans, and even sharks, providing nursery areas and nutrient support (Rahardjo, 2009; Pratiwi, 2006).

Coral reefs also play a critical role in coastal ecosystems by providing breeding, spawning, and feeding grounds for marine species, particularly those of high economic value (Farsia & Wardah, 2014). The RZWP3K (2018) report classifies 51% of Aceh's coral reefs as good condition, 18% as moderate, and 31% as degraded. Aceh's average hard coral cover ranges from 25–50%, placing it within the moderate category.

The assessment of unique or special habitats, such as spawning, nursery, and feeding grounds for thresher sharks, remains inconclusive due to a lack of data. Ichsan et al. (2020) emphasized the need for annual studies on shark fishing grounds, including sex ratios and size distribution, to better understand their population dynamics. The absence of detailed habitat mapping hampers effective management and conservation efforts (Fahmi & Dharmadi, 2013).

Based on the composite assessment, the habitat and ecosystem aspect scored 66.67, which is classified as "good." However, individual indicators show varying conditions. Seagrass and coral reef ecosystems scored 2 ("moderate"), indicating the need for better management. Mangrove ecosystems received a score of 3 ("good"), while unique habitats scored 1 ("low"), highlighting a critical gap in conservation efforts.

Fishermen and stakeholders reported lacking information on key thresher shark habitats, including spawning, nursery, and feeding grounds. Additionally, no direct surveys have been conducted to identify these areas. According to Budiarto *et al*. (2015), knowledge of unique shark habitats is vital for sustainable stock management. It should guide measures such as seasonal fishing closures, gear restrictions, designated fishing zones, and marine protected areas. Improving habitat and ecosystem management is crucial to sustaining Aceh's marine resources, particularly shark populations. Strengthening research, monitoring, and conservation initiatives will provide a stronger foundation for sustainable fisheries management.

CONCLUSION

This study highlights the importance of PPS Kutaraja as a key landing site for thresher shark fisheries. Thresher sharks are primarily caught as bycatch using purse seines and longlines, contributing to a complex trade network involving local and international markets. Assessing habitat and ecosystem conditions indicates that while mangrove ecosystems are in good condition, seagrass and coral reef ecosystems require better management.

The EAFM-based composite assessment resulted in a score of 66.67, categorized as "good," but identified a critical gap in data regarding thresher shark habitats. Effective management strategies, such as habitat conservation, trade regulation, and improved monitoring, are necessary to ensure the sustainability of shark fisheries. Strengthening

research on key shark habitats and implementing ecosystem-based fisheries management will be crucial in balancing conservation efforts with economic benefits for local fishing communities.

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