Thresher sharks (Alopiidae) catch in the pelagic fisheries of Western Indonesia

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Abstract. Thresher sharks (family Alopiidae) are an evolutionarily distinct and globally endangered species group. Indonesia is the world’s largest shark fishing nation, and a global priority for reducing the capture of threatened shark species. Kutaradja port is one of Indonesia’s largest fishing ports, located in the capital of Aceh Province, Banda Aceh, Western Indonesia. Kutaradja is a large oceanic port serving a variety of fisheries, from small scale to industrial fleets. One of the main fisheries operating from Kutaradja port is an industrial purse seine fleet targeting valuable pelagic fish, particularly tuna. Pelagic sharks such as threshers are vulnerable to capture in these fisheries, due to their co-occurrence with stocks of valuable pelagic species. Here we describe the volume and composition of shark catch in Kutaradja’s purse seine fleet, based on daily landing monitoring conducted in January 2017 to May 2019. Our results show that the dominant species caught are thresher sharks (Alopiidae), which make up 51% of all shark landings. A total of 627 thresher sharks were landed during the monitoring period, consisting of 558 individuals of pelagic threshers shark (Alopias pelagicus) and 69 individuals of bigeye thresher shark (Alopias superciliosus). The catch is dominated by mature females, which could be particularly detrimental to the reproductive capacity of the population. Fishers in purse seine vessels often catch these threshers with hand-lines, which are used as a secondary gear while the main fishing gear is soaking. Based on these findings, we proposed recommendations for reducing thresher shark fishing mortality, including restricting the use of secondary fishing gears and releasing incidentally captured sharks.

1. Introduction
Indonesia has the world’s largest catches of elasmobranchs (Class Chondrichthyes, herein ‘sharks’). Between 2000 and 2011 reported national shark production averaged 106,034 tonnes per year [1]. The Aceh Province contributes a significant proportion of national shark catch and is a priority area for shark fisheries management in Indonesia (REFS). The largest known shark and ray landing site in Aceh is the Kutaradja fishing port in Banda Aceh, the provincial capital [2, 3]. Where sharks are landed by targeted fisheries. However, most sharks landed in Kutaradja are bycatch from purse seine vessels.

The purse seine fleet is the largest fleet operating from the Kutaradja fishing port, with a total of 264 vessels ranging from 6-131 GT. These vessels mainly operate in the Indian Ocean and target valuable pelagic fish such as tuna, cob, skipjack, and mackerel scad. The average total production of the fleet is around 9.29 tonnes per year, worth an estimated value of IDR118.98 billion or around
USD 8.4 million per year [2-4]. One of the most commonly landed shark species is thresher sharks (family Alopiidae), specifically the pelagic thresher shark (*Alopias pelagicus*) and the big eye thresher shark (*Alopias superciliosus*) [2, 3]. These species are a priority for conservation and fisheries management in Indonesia because they are evolutionarily distinct [5] and are also threatened with extinction [6]; being both listed in appendix II of the Convention on the International Trade of Endangered Species (CITES). Recognizing this priority, this research aims to describe the characteristics of thresher shark landings in Kutaradja port, Aceh, and propose some management recommendations to reduce fishing mortality of these species in the purse seine fleet.

2. Methods

2.1. Data collection

Daily landings monitoring was conducted in the Kutaradja port, Banda Aceh between January 2017 and May 2019. Data collection for fisheries and biological variables followed the methods outlined in the Southeast Asian Fisheries Development Center (SEAFDEC) Standard Operational Procedure for Sharks and Rays Data Collection [7]. For all sharks that were landed, biological variables were collected including species, body length, sex and stage of maturity. Operational fishing characteristics were also collected by interviewing each boat owner, captain and member of the crew, recording the name of the vessel, gear type, effort (as the number of days fishing), operational costs and fishing grounds.

2.2. Data analysis

We described the overall composition of shark landings in the Kutaradja port, and in particular of thresher sharks landings through calculating catch per unit effort (CPUE), sex ratio, and size structure of landed individuals.

2.2.1. Sex ratio. We analyzed the sex ratio of landed sharks by comparing the total number of male and female sharks from all collected samples. To determine if the total catch varied by sex, we divide the number of males by the number of females landed.

2.2.2. Size structure. We analyzed the length-frequency distribution of landed sharks based on the total length (TL) of each recorded individual. We looked at the frequency of landed individuals for each length class interval, the median class, and how these compare to published estimated length at first maturity.

2.2.3. Catch per unit effort. We conducted a simple analysis of catch per unit effort based on the total recorded shark landings (number of individuals) per fishing trip as per equation 1. The catch was expressed as the number of individuals instead of weight.

\[ \text{CPUE} = \frac{C}{F} \]  

Where:

- CPUE : Catch Per Unit Effort (Individuals per trip)
- C : Total Catch (number of individuals)
- F : Effort (number of trips)

3. Results

3.1. Catch Composition

During the data collection period, a total of 1,234 individual sharks were recorded in Kutaradja caught by the purse seine fleet. Shark catches comprised approximately 2% of total recorded purse seine fleet
landings. Shark catches consisted of 27 species across 11 families; these include families Aloiidae, Carcharhinidae, Centrophoridae, Dalatiidae, Ginglymontomatidae, Hemigaleidae, Hemiscylliidae, Lamnidae, Sphyrnidae, Squalidae, and Triakidae. The most commonly landed species of shark from the purse seine fleet were thresher shark (Family Aloiidae). A total of 627 thresher sharks were landed during the monitoring period, consisting of 558 individuals of pelagic thresher shark (*Alopias pelagicus*) and 69 individuals of bigeye thresher shark (*Alopias superciliosus*). Together, these made up 51% of the total shark landings by purse seine fleet. Other commonly landed species included the requiem sharks (family Carcharhinidae), which made up 34% of the total shark landings.

3.2. Sex ratio and length distribution

For the pelagic thresher (*Alopias pelagicus*), the sex ratio was 1:1.39, whereas for the bigeye thresher (*Alopias superciliosus*) was 1:3.07. The chi-square test results showed that the skew towards females for *A. superciliosus* was significant (2.25; 3.84) but not for *Alopias pelagicus* (145.78; 3.84). The total number of pelagic thresher sharks (*Alopias pelagicus*) landed during the study was 526 individuals. The total length (TL) of sharks caught ranged between 96 and 350 cm, with an average of 263.47 cm (STDEV= 26.41). The most frequently landed size class was between 261-275 cm (Figure 1a-b). The length of the first maturity for this species is 232 cm for males and 244 cm for females [8]. For bigeye thresher sharks (*Alopias superciliosus*), the total number landed during the study was 67 individuals, with a TL ranging between 126 and 366 cm, with an average of 260.44 cm (STDEV = 35.95) (Figure 1c-d). The most frequently captured size class was between 262 and 276 cm. The length of the first maturity for bigeye threshers are 279 cm and 332 cm for males and females, respectively [9, 10, 11].

![Figure 1](image_url)

**Figure 1.** Size structure for landed thresher sharks. Top: *Alopias pelagicus* male (a) and female (b). Bottom: *Alopias superciliosus* male (c) and female (d).
3.3. **CPUE per trip**

The catch per unit effort (CPUE) of thresher sharks from 2017 to 2019 indicates a slight decline although it is not significant with a range of 2.55 – 3 individuals caught per trip (Figure 2). Note that in 2019 the data collection is only from January-May 2019.

![Figure 2](image.png)

**Figure 2.** CPUE of the number of thresher sharks caught per trip in purse seine vessels.

4. **Discussion**

The Kutaradja fishing port is one of the biggest in Indonesia’s, and a major shark landing site. Vessels operating from Kutaradja generally catch fish using purse seine and some other fishing equipment such as fishing rods. The main catches of the purse seine fleet in Kutaradja are tuna, cob fish and skipjack while sharks are incidentally caught. Within the shark purse seine bycatch, thresher sharks (Alopiidae) constitute the bulk of all shark species caught.

Thresher shark (Alopiidae) is a type of oceanic shark that lives from coastal waters to open seas, from a surface layer up to a depth of 600 m [12]. This type of shark has been listed in Appendix II of CITES in 2016, which means the international trade of these species is still allowed but should be with the strict arrangement. At the national level, the regulation of these species has been arranged in article 73 of the MMAF Ministerial Decree PER.30/MEN/2012, that fishermen must release the caught shark if it is still in living condition and record and report to port authorities when the shark is dead.

The thresher shark is prone to exploitation, both target and bycatch fisheries. According to [13], the shark is a type of shark that is often migratory and epipelagic from the surface to a depth of 152 m (*Alopias pelagicus*) and 600 m (*Alopias superciliosus*). Thresher shark is easily caught by the purse seine due to its long tail, so it becomes easily snared in the net [14]. The distribution of thresher sharks shows a vertical migration pattern similar to that of tuna and other pelagic fishes, causing the shark always be caught in the side-capture of the purse seine or other fishing gear such as hand line [2, 15].

From the biological analysis such as sex ratio and length distribution, we can conclude that female is more abundant in both species, more mature shark in pelagic thresher while more immature and sub-mature shark in bigeye thresher. For pelagic thresher, it is worrying about taking large numbers of mature or sub-adult females out of the population, since this could negatively impact the reproductive capacity of the population and for bigeye thresher, more sub-adults could either be a sign that this length class is more susceptible to capture in this fishery or a sign that there are fewer mature adults in the population that could lead to population decline.

Our results also indicate that within the Indian Ocean, thresher sharks are susceptible to being caught by purse seines, more so than other pelagic shark species. Fishers in purse seine vessels often catch these threshers with hand-lines, which are used as a secondary gear while the main fishing gear is soaking. This evidence the need for closer monitoring and management for this threatened species. Sharks, in general, are vulnerable to overfishing, as many have a slow rate of intrinsic population growth. This is due to many species producing a low number of pups per litter and having long reproductive cycles when compared with bony fishes [16]. Almost all fished shark populations have
shown a steep decline over the past decade [17], due to overexploitation in both targeted fisheries and those in which sharks are incidentally caught.

It is highly advised to reduce the capture of threshers in this fishery, especially mature, fecund females. To achieve that, we need to understand better the susceptibilities of the different species, sexes and length classes to capture, and which types of fishing activities (e.g. fishing ground, soak time, etc.) are more likely to lead to capture and mortality, especially for fecund females. We also need to understand options for promoting escape from purse seines and/or post-capture release and survival since threshers may have quite low post-capture survival, though we would need to test this for purse seine.

Based on these findings, we proposed recommendations for reducing thresher shark fishing mortality, including restricting the use of secondary fishing gears and releasing incidentally captured sharks. In the end, it is very important to understand the potential socio-economic implications, given the lucrative market for shark fins and high shark meat consumption in Aceh. More investigation on the fisheries pattern such as fishing ground and time of the year compared to sex ratio and length distribution in both species. In the future, such information will be crucial to mitigating the unintentional catch of vulnerable species.

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