# Biological Aspects and Catch Fluctuation of the Pelagic Thresher Shark, *Alopias pelagicus* from the Indian Ocean

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***ABSTRACT***
The pelagic thresher shark *(Alopias pelagicus)* is an oceanic shark and is generally caught as a by-catch by tuna gill net fisheries operating in the Indian Ocean. This research was conducted from April 2002 to December 2007 at Cilacap-Central Java fish landings. Biology and catch data were collected through direct observation and the use of enumerators. The results showed that the relationship between the total length and the clasper's length was sigmoid; this means that with the increase in total body length, the clasper length also increases in size until it reaches its maximum length. The relationship between the total length and the precaudal length of both the male and female were linier ($R^2$= 0, 9803 and $R^2$= 0.9423 respectively). The length frequency of the male *Alopias pelagicus* was lowest at a size range of 150-170cm total length (immature), while the highest frequency was seen ranging between 251-270 cm in total length with a 260 cm mode (mature, non reproductive). The lowest frequency of female *Alopias pelagicus* was found at a size range of 291-310 cm in total length (mature), with the highest length frequency appearing between 231-250 cm. The sex ratio of males to females of *Alopias pelagicus* was 1: 1 (P>0.05). Catches of these species have decreased by 34.9% in the last six years. This indicates that the abundance of *Alopias pelagicus* previously existing in the Indian Ocean was significantly in decline.

**KEYWORDS**: **biological aspects, catch fluctuation, pelagic thresher shark, Indian Ocean**

## INTRODUCTION

The Family of Alopiidae consists of three species: *Alopias vulpinus, A.superciliosus* and *A.pelagicus*. In Indonesian waters however, there are only two species found, *A.pelagicus* and *A.superciliosus*. Although the conservation status in Indonesia for these species has not yet been evaluated, the IUCN red list includes the three species and classifies them as being 'vulnerableto extinction'. The family Alopiidae is a group of active, predatory sharks which have long tails that can be used to collect prey. Although all *Alopias* species generally have a close relationship and similar characteristics, essentially they are quite different (Hanan *et al*, 1993). Reproduction of Alopiidae is ovoviviparous, where stored food in the egg sac (yolk sac) is absorbed by the fetus (Bigelow and Schroeder, 1948; Otake and Mizue, 1981).

Visually, the differences between *A.pelagicus* and *A.superciliosus* lies are most obviously seen from the shape of the head and the differences in eye size. The pelagic thresher shark is a large, wide-ranging Indo-Pacific Ocean shark, apparently highly migratory, with low fecundity (two pups/litter) and a low (2-4%) annual rate of population increase (Reardon, *et al.*,2009). Although this species is reported to be relatively common to some coastal localities, current levels of exploitation in certain areas are considered unsustainable. It is known that thresher shark populations of the Indian Ocean are separated by depth and space, according to gender. When hunting schooling fish, thresher sharks are known to slap the water, herding and stunning prey (Anon, 2012 ).

*Alopiaspelagicus* is vulnerable to exploitation (both target and by-catch) because its habitat occurs within the range of many largely unregulated and under-reported gillnet and longline fisheries. The shark is generally caught in tuna gillnets and tuna longlines as a by-catch operated in the Indian Ocean. Pillai and Honma (1978) reported that average catches including *A.pelagicus* in the Indian Ocean ranged from 0.1 to 5.0 fish per hook during the operation. This

species is poorly known, but it is thought to be highly migratory and is epipelagic from the surface to at least 152 m depths (Compagno, 2001). Factors such as temperature and oceanic current influence its distribution. For example, it is found near the Equator in winter, but not in summer (Dingerkus 1987). Information on biological aspects of *A.pelagicus* caught in the Indian Ocean is still lacking (Castro *et al.*, 1999) and is currently unavailable in Indonesia.

This paper aims to provide information regarding the length frequency distribution, relationship between total length and pre caudal length, sex ratio, the maturity stages of males and females, and the catch fluctuation of the pelagic thresher shark (*Alopias pelagicus*).

## MATERIALS AND METHODS

The research was conducted from 2002 to 2007 at the Cilacap-Central Java fish landing sites (Fig. 1).

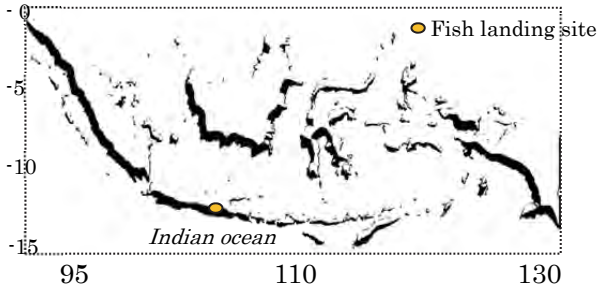



Fig. 1. Map of the study area and observed landing sites

A total number of 399 individuals, consisting of both male and female thresher sharks caught by seine net and tuna longline, were observed during the sampling periods. Length frequency, sex ratio, clasper length and gonad maturation of these fish were analyzed. Clasper measurements in cm were taken from the curve of the inside of the pelvic fin to the tip of the clasper. The data were analyzed based on daily input data recording from the enumerators of 66 vessels operating in the Indian Ocean. Data analysis to determine the correlation among some parameters was conducted using a statistical regression based on MinitabRelease13 software. Meanwhile, determining the stage of clasper maturity based on its development was completed microscopically, with reference to Martin and Coilliet; Snelson *et.al.* (1988) as shown in Table 1.

## RESULTS

### Morphology

Morphologically, the body of *Alopias pelagicus* was cylindrical and rather fat, with a fairly long, conical and tapered snout. The mouth of the ventral contains small or medium sized teeth each shaped like a flat blade, with less than 60 rows in each jaw. The shark has five gill slits, with the last 2 located above the pectoral fin. The first dorsal fin was situated roughly in the middle of the body or slightly to the rear and stands tall and upright. The first dorsal-fin's origin is closer to the rear tip of the pectoral-fin than to the base of the pelvic-fin.

The pectoral fins are long and narrow. The upper lobe of the tail fin was as long as the shark's body length and its color was dull. The white part of the shark's belly did not extend over the base of the pectoral-fin.

Table 1. Maturity stage male of elasmobranch (Martin and Coilliet, 1988)

| Stage | Macroscopic stage |
|---|---|
| **Males** | |
| 1. Immature | Testes undeveloped. Claspers small and uncalcified. |
| 2. Maturing,virgin | Testes enlarging but without prominent lobes, vas deferens becoming coiled. Clasper enlarging and undergoing. Calcification and thus becoming rigid. |
| 3. Mature, non | Testes contain large bulging lobes due to reproductive production sperm. Vas deferens are tightly coiled. Clasper fully developed and rigid due to calcification. |
| 4. Mature, sexually | Seminal vesicles full of mature spermatozoa. Testes with bulging lobes and clasper enlarged and rigid. |

Morphological characteristics that could specifically distinguish *A.pelagicus* from other species (*Alopias vulpinus* and *A.superciliosus* were as follows: *A. pelagicus* has weak, horizontal grooves on each side of the neck, eyes and teeth were small and teeth numbered more than 29 pieces in each jaw. The first dorsal fin was located in the center of the base of the pectoral fins and belly fins. Chest fins were long, narrow and round tipped. They had white, abdominal coloring which did not extend to the base of the pectoral fin (Fig.1).

The genus of *Alopias* could be distinguished mainly from the color on the back surface of the body. The back of *Alopias vulpinus* was a dark green color , while *Alopias superciliosus was* gray and *Alopiaspelagicus* generally appeared blue**.** *A.pelagicus* could only reach a maximum length of 3 m (Compagno, 2001). Genus *Alopias* shows slow sexual maturation and the sexual maturity of *Alopias pelagicus* males was reached between the ages of 7-8 years and females between 8-9 years. The size of *A.pelagicus* upon reaching sexual maturity was estimated to range from 264-282cm in total length (Otake and Mizue, 1981; Compagno, 1984a). Coilliet *et al.* in Camhi *et al.*, (2008) reported that in Pacific waters, the female of Alopiidae generally achieved genital maturity at a total length of 260-315 cm or at 3-4 years old, and in males genital maturation data shows maturity is reached at a total length of 333cm at approximately 7 years of age. Family *Alopidae* sharks potentially can live up to 20 years or longer.

Fig.2. Morphology of the pelagic thresher shark (Last and Stevens, 2009)

**Length frequency distribution**

According to the catch data from the Cilacap landing site, the lowest distribution in the size of pelagic thresher shark, *Alopias pelagicus,* body length was seen in the male group at between 150-170cm with 160 cm modes (for immature group), with the highest distribution in length occurring at 250-270 cm with a mode of 260cm in the mature, adult groups. The highest distribution of female body lengths occurred at 231-250 cm with a mode of 240 cm, while the lowest distribution of body length occurred at 291-310 cm with a mode of 300cm for mature, adult groups (Fig.3).

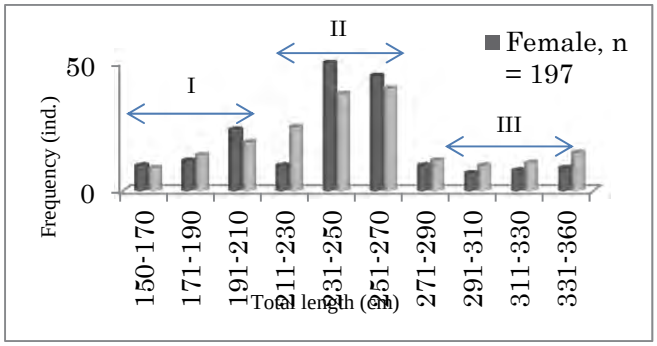



Fig.3. Length distribution of male and female Pelagic Thresher Shark

Distribution of the body length of pelagic thresher sharks, *Alopias pelagicus* is showed in Fig. 3. There are at least three age groups (*cohort*) of *A.pelagicus,* both males and females.

**The relationship of total length and pre caudal length**

The relationship between total length and pre caudal length in female and male pelagic thresher sharks is presented in Fig.4. The relationship of the two parameters of both sexes was linear so that the values of $R^2 = 0.9423$ for females and $R^2 = 0.9803$ for males show that by increasing the total length, the standard length also increased. Based on the value of $R^2$ of the two sexes, it can be said that both male and female pelagic thresher sharks had similar body lengths.

The relationship between total length and clasper length of *Alopias pelagicus* can be seen in Fig.6. The figure shows that the total length and clasper length relationship of *Alopias pelagicus* was sigmoid, This means that with the increase in total body length, clasper length also increases until it reaches its maximum length. There were three stages in the size of the clasper development according to the calcification process of the claspers, i.e. non-calcified = NC, non-fully calcified = NFC, and fully calcified = FC. NC was found in sizes between 150-240 cm, NFC between 220-270 cm and FC between 220-340 cm respectively. According to the development of the body length, there were three size groups of the transition size at the clasper maturity stage. The transition size was related to a condition occurring when claspers were mature but not yet ready to reproduce until reaching full maturation (stage 3-4) at a size of between 225-275 cm.

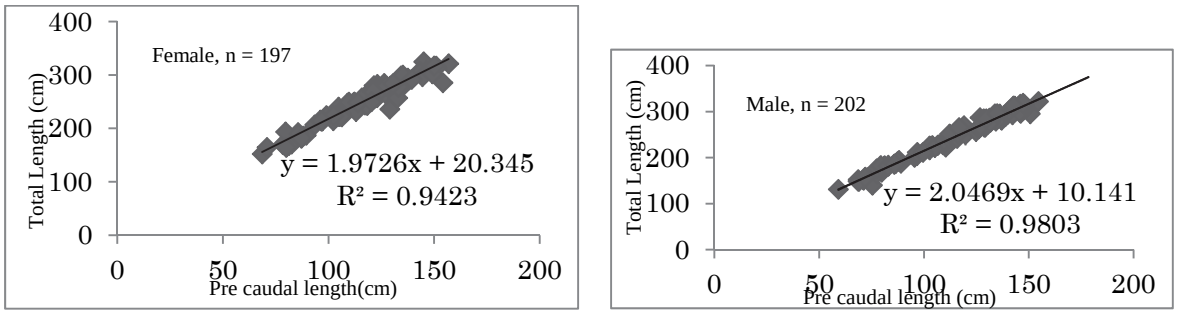
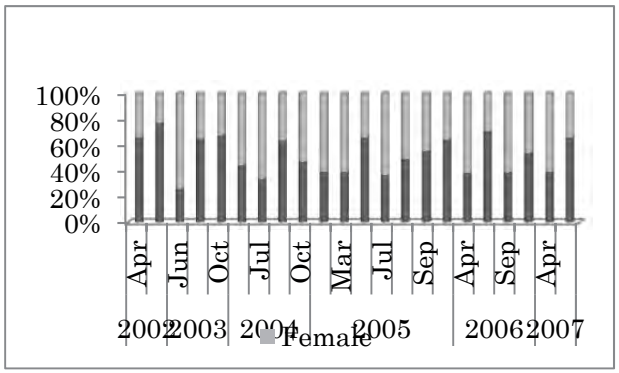
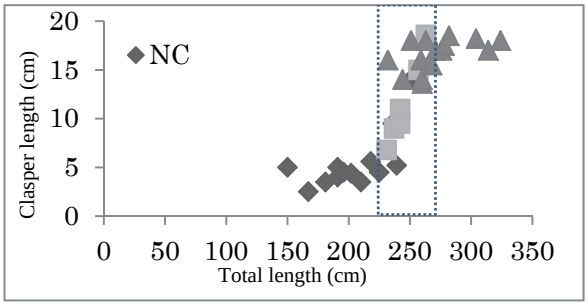



Fig. 4. Relationships between total length and pre caudal length of the thresher shark, *Alopias pelagicus.*

**Sex ratio**

Themonthly sex ratios of male and female of pelagic thresher sharks during the years 2002-2007, is presented in Fig. 5. Sex ratios of thresher sharks *Alopias pelagicus* caught in the Indian Ocean were varied. The recruitment process will prove successful for reproduction if the ratio of males and females is equal (1:1) (Sparre and Venema, 1992). The recruitment process was also influenced by other factors including the availability of the parent, predators and habitat conditions in the environment. Furthermore, Sparre and Venema (1992) believe that the recruitment process of a species is influenced by several factors such as fishing activity, type of




fishing gear used and the size of fish caught.

Fig.5. Monthly sex ratios of male and female pelagic thresher sharks, *Alopias pelagicus* over six years.

Fig.6. The relationship between total length and clasper length of the pelagic thresher shark, *A. pelagicus.*

The monthly sex ratios of male and female for the period from April, 2001 until July, 2004 were fluctuated and unbalanced. In the period from September, 2001 to August, 2005, sex ratios between males and females were balanced.

**Catch Fluctuations**

Catch fluctuations of pelagic thresher sharks (*Alopias pelagicus*) during the years 2002-2007, can be seen in Fig.7 below. In general, the total catch of pelagic thresher sharks increased from April to September each year and then reduced significantly in October.

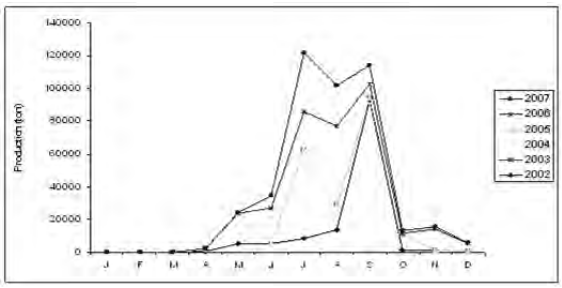



Fig.7. Monthly catch fluctuation of *Alopias pelagicus* caught by tuna drift gillnets from 2002-2007.

## DISCUSSION

In order to determine the growth parameters of a fish, the body length frequency distributions can be examined (Sparre and Venema, 1992). This condition is also applied to the pelagic thresher shark.

The highest length frequency of *Alopias pelagicus* males and females was between 250-270 cm and 231-250 cm respectively. Based on the length frequency of both sexes, females of *A. pelagicus* are commonly larger than the males. Liu *et al* in Camhi *et al.*, (2008) state that the growth of females of family *Alopiidae* is faster than the growth of males. According to their maximum size, *Alopias pelagicus* from the Indian Ocean can reach a maximum length of 365cm. Males reach adulthood at a size of about 240-250 cm and females at 260-285 cm (White *et al.*, 2006; White, 2007). Liu *et al.*, (1999) reported that total lengths at maturity were 282-292 cm for females and 267- 276 cm for males. Thus based on the results of this study, it can be concluded that most of *Alopias pelagicus* caught from the Indian Ocean from the years 2002-2007, have reached adulthood (mature non-reproductive or mature sexually). Based on these results, it could be concluded that fishers should not catch *A.pelagicus* in a size of less than 275 cm in order to provide opportunities for these species to copulate. In Indonesian waters, pelagic thresher sharks are often caught by tuna drift gillnets. They are easily caught due to their long tails which cause them to become easily entangled in the nets. In general, the fishermen operating in the Indian Ocean used fish nets with a mesh size of 5 inches for a targeted catch, mainly consisting of

skipjack tuna.

Differences in water conditions from one area to another can affect the difference in the size of sex maturity in both males and females (Dharmadi and Fahmi, 2007). Pitcher and Hart (1982) stated that, when young fish are caught before reaching optimum growth, a "*growth over fishing*" will occur, i.e. over fishing of a group of fish which are still immature. This will reduce the opportunity for the mature fish to reach gonad and genital maturation, which will lead to the occurrence of "*recruitment over fishing*", because the number of new individuals generated is insufficient to enable the sustainability of the population. This condition may occur in the "*open access waters*" if the fishing activities tend to be in excess, regardless of the balance of population and without obeying the rules regulating fisheries management. An example of this is the regulation of the use of mesh size and the limit in number of fishing gear permitted for use in the optimal fishing areas of a region, namely "*Fisheries Management Zones"*.

The success of the recruitment process of a species is likely to be influenced by several factors such as the fishing area, the fishing gear used and the size of fish caught (Sparre and Venema, 1992). The recruitment process of a species may also be influenced by the quality of the water environment, availability of brood stock and the presence of prey.

The relationship between clasper length and body size is usually used to determine the size at which male fish reach genital maturity (Stevens and McLoughlin, 1991). Although both the claspers on the left and the right function in reproduction, only one is inserted into the cloaca of the female during copulation or during the mating process.

Comparative information on sex ratios in fish is needed to understand their population development. Comparison of sex ratios is a very important aspect for the ability of individuals to participate in the process of recruitment within the population (Anon., 2009). The recruitment process of a species will be successful if the ratio of the number of males and females is proportionately balanced. This suggests that the sex ratio of *Alopias pelagicus* always experiences change at a certain period. This can be caused by intrinsic factors, namely the comparison of male and female sex ratios at birth. The proportion of males and females at birth can be an important indicator in the process of reproducing within a fish population (Anon, 2005). Furthermore, Brykov *et al.*, (2008) stated that the sex ratio is related to the amount of fish produced in the future generation and as a control population size. Extrinsic factors such as fishing apply pressure, so that male and female population distribution becomes uneven. Differences in fishing techniques and fishing gear electivity may also influence the sex ratio differences in the species caught. This is allegedly associated with the natural conditions of the Indian Ocean winds that accompanied the production of strong waves. This condition prevents fishermen from undertaking fishing activities at sea. Fishing activity started to increase in May, however, catch fluctuations of *Alopias pelagicus* over six years show a similar pattern in that the increase of total catch began from July through September, then declined in subsequent months. In general, the total catches of *A. pelagicus* tend to decrease from year to year. Fig. 5 shows that the catch data of *Alopias pelagicus* caught during the six years (2002-2007) fluctuated. From January to June the catches are relatively low, as is also seen occurring from October to December each year. In 2002, the catch of *Alopias pelagicus* weighed 128.443 tons and in 2007 it was equal to 83.556tons. *Alopias pelagicus* caught in the Indian Ocean decreased by 34.9% over the six years. The significant decline in the annual catch of this species has become a serious concern, given that their biological nature makes them vulnerable to extinction. Therefore, management measures are necessary to ensure the availability of fish resources. According to King (1995), fish resources can be renewable, as long as their use does not cross the limits of their ability for recovery. Fisheries management aims to ensure that fisheries resources can be utilized optimally by taking into account the sustainability of resources and preserving the environment. According to Purwanto (2003), fishery management measures can be categorized into two controls, i.e.: 1). control of fishing techniques and 2). control of fishing efforts. In principle, fisheries management aims to regulate the intensity of fishing catches in order to obtain optimal results from a number of various aspects (Widodo, 2000). Relating to the management of shark fisheries in Indonesia, since 2007 the Directorate General of Capture Fisheries has produced a draft handbook on national shark fisheries management actions (National Plan Of Action shark and ray), which was published in 2010. However, the NPOA shark and ray in Indonesia has not been implemented yet, on account of the large number of fish landing sites and the requirements for field officers to be

able to accurately identify species of sharks and rays to be met .

## CONCLUSIONS

The majority of *Alopias pelagicus* caught from the Indian Ocean and landed at Cilacap were categorized as immature. Based on the length frequency, there were three size cohorts that indicated the maturity stage. Catches of *Alopias pelagicus* over the last six years tended to decrease by 34.9%. This indicates that the abundance of this species in the Indian Ocean has declined. The large numbers of young thresher sharks caught in the Indian Ocean will affect the recruitment process of this species. Therefore, we suggest that fishermen not catch pelagic thresher sharks that are less than 275 cm in size TL as the mature size limit for the pelagic thresher shark.

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