Age, growth, and mortality of starspotted smooth-hound, *Mustelus manazo* (Bleeker, 1854) in southern West Nusa Tenggara waters

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Abstract. *Mustelus manazo* (Starspotted smooth-hound shark) is one of the important catch for small scale fisheries in West Nusa Tenggara. This species belongs to the family Triakidae. According to the IUCN Red List, the conservation status of this species is data deficient, which means that there is insufficient information to conduct a proper assessment of conservation status. The objective of this study is to estimate the age, growth and mortality of *M. manazo* in southern West Nusa Tenggara waters. Length data were collected from January to December 2016 in Tanjung Luar Port, West Nusa Tenggara. Electronic length-frequency analysis (ELEFAN) in R Statistics with package “TropFishR” was used to estimate the population parameter. Length converted catch curve analysis was used to estimate the total mortality. The results showed that von Bertalanffy growth model for male was $L_t=122 (1-e^{(-0.1(t+0.01))})$, for female was $L_t=130 (1-e^{(-0.18(t+0.02))})$ and for combined sex was $L_t=132 (1-e^{(-0.1(t+0.01))})$. Total mortality was estimated at 0.25 year⁻¹. The results from this study represent basic information to support fisheries management of *M. manazo* in Indonesia.

1. Introduction

Indonesia is one of the contributors in shark fisheries in the world, especially in shark finning. From 2000 to 2011, the annual average export of Indonesian shark fins reached 1,235 tons with a value reaching $10 million [1]. Some of the fish landing sites that are identified as shark production spots are the ports of Benoa, Bali, the port of Cilacap, Central Java, and the port of Tanjung Luar, West Nusa Tenggara. In Benoa and Cilacap, sharks represent bycatch of tuna longline fisheries [2,3]. While in Tanjung Luar, sharks are one of the main catches of traditional fishers using set longlines and drifting longlines [3,4].

The exploitation of sharks has been an important issue in global fishery management due to their biological characteristics [5,6]. This group is very susceptible to overfishing mainly because of their life cycles. Some of them present slow growth rates and reproduction processes and produce a small number of juveniles [7]. One of the most important shark species for small-scale fishers in West Nusa Tenggara (NTB) is the starspotted smooth-hound (*Mustelus manazo*). According to the International
Union for Conservation of Nature (IUCN), the conservation status of this species is data deficient, which means that there is insufficient information to adequately manage its population [8].

Among the most useful aspects supporting fisheries management is the knowledge of the age and growth of a fish species [9]. Age and growth can be used to estimate recruitment, life span, and mortality, which in turn can be used to determine the level of exploitation of a fish stock [10]. Some hard parts of fish body can be used to determine the age, namely otoliths and vertebrae [11–13]. Nevertheless, both of these materials require expensive costs and a very long time to be processed [14]. Another method that can be used to determine the age and growth of a fish species is to use the extended frequency analysis [15]. This study aims to estimate the age, growth and mortality of starspotted smooth-hound shark (*M. manazo*) in southern West Nusa Tenggara waters.

2. Materials and methods

Data collection was carried out by measuring the total length (TL) with 1.0 cm accuracy and determining the sex of the starspotted smooth-hound at Tanjung Luar Fish Landing Port (Figure 1), West Nusa Tenggara (NTB) from January to December 2016. The starspotted smooth-hound landed was caught by longlines that operate in the southern Nusa Tenggara waters. The process of identifying starspotted smooth-hound was done by referring to the shark identification book from Compagno [16] and White et al. [17].

![Figure 1. The study site in Tanjung Luar Fish Landing Port, West Nusa Tenggara](image)

*Linf* and *K* population parameters were calculated by Electronic Length Frequency Analysis (ELEFAN) in the R statistics program with the "TropFishR" package. ELEFAN analysis can be used to calculate *Linf* and *K* values to estimate growth parameters by the formula according to Mildenberger et al. [18] as follow:

\[
\text{Manazo\_ELEFAN} = \text{ELEFAN (} x = \text{Manazo\_data, Linf\_range} = \text{seq (min, max, ran), K\_range} = \text{seq (min, max, ran)})
\]
where $x$ is list of information consisting of the length of the temptation, and the time to be caught, $L_{inf}$ _range is vector value to determine the $L_{inf}$ value consisting of minimum, maximum and range values, and $K_{range}$ is vector value to determine the value of $K$ which consists of the minimum, maximum and range values. The theoretical age at a length of 0 cm ($t_0$) was calculated using the Pauly formula [19] as follows:

$$\log (-t_0) = -0.3922 - 0.2752 \log L_{inf} - 1.038 \log K$$

which is: $t_0$ is hypothetical age at a length of 0 cm, $L_{inf}$ is asymptotic length, and $K$ is growth rate. The determination of starspotted smooth-hound mortality uses a length-converted catch curve analysis from Pauly [20].

3. Result

1.1. Length frequency

Total length was measured in a total of 584 starspotted smooth-hound, consisting of 257 males and 327 females. The average total length of male starspotted smooth-hound was 89.7 cm, with a range of 59-115 cm, while the average total length of female starspotted smooth-hound was 98.5 cm, with a range of 56-128 cm (Figure 2).

![Figure 2](image)

**Figure 2.** The total length (cm) of *M. manazo* landed in Tanjung Luar Port in 2016.

1.2. Age, growth, and mortality

Von Bertalanffy growth curve obtained for male sharks indicates a maximum length ($L_{inf}$) of 122 cm, with a growth coefficient ($K$) of 0.10 year$^{-1}$ and theoretical age at length 0 cm ($t_0$) of -0.01 year. For female sharks, $L_{inf} = 130$ cm, $K = 0.10$ year$^{-1}$ and $t_0 = -0.01$ year. Whereas, for combined sexes, were obtained $L_{inf} = 132$ cm, $K = 0.10$ year$^{-1}$ and $t_0 = -0.01$ year (Figure 3). The total mortality (Z) of *M. manazo* derived from the value of the linearity gave a result of 0.25 year$^{-1}$ (Figure 4).
4. Discussion
In general, the length of female starspotted smooth-hound shark is longer than that of males. The average length of female starspotted smooth-hound was 98.5 cm while the average length of male starspotted smooth-hound was only 89.7 cm. Similar conditions also occur in this species in several other locations such as in Java [21].

Similar conditions also occur at the asymptotic length (Linf) of this species, where female starspotted smooth-hound is expected to grow larger than male. The asymptotic length (Linf) of the female starspotted smooth-hound is 130 cm longer than the male starspotted smooth-hound which only reaches 122 cm asymptotic length. The same thing happened in other locations (Tabel 1) such as Tokyo, Japan, where the asymptotic length of female starspotted smooth-hound shark is 251 cm while that of male is 191 cm [22]. In Nagasaki, Japan, the asymptotic length of female starspotted smooth-
hounds are 216 cm while in the male is 184 cm [23]. In Chosi, Japan, the asymptotic length of female starspotted smooth-hound shark is 139 cm, while in the male is 118 cm [24].

The growth rate (K) of starspotted smooth-hound found in this work was 0.1 year⁻¹ for both males, females, and combined. This value is similar to the growth rate of this species in several areas of Japan, namely 0.07-0.22 year⁻¹. According to King [14], sharks do have a slow growth rate compared to other fish groups. Examples of other shark species that have a slow growth rate are the silky sharks (Carcharhinus falciformis) with K = 0.08 year⁻¹ [25], the blue shark (Prionace glauca) with K = 0.12 year⁻¹ [26], and the bull shark (Carcharhinus leucas), with K = 0.07 year⁻¹ [27].

| Location          | N  | Sex | Linf (cmTL) | K (year⁻¹) | t₀ (year) | Methods | References |
|-------------------|----|-----|-------------|------------|----------|---------|------------|
| Tokyo, Japan      | 191| M   | 124.0       | 0.12       | -2.59    | Vertebral | [22]       |
|                   | 251| F   | 134.0       | 0.113      | -2.55    | Vertebral | [23]       |
| Nagasaki, Japan   | 184| M   | 84.6        | 0.22       | -3.69    | Vertebral | [24]       |
| Japan             | 216| F   | 99.9        | 0.2        | -2.88    |          |            |
| Chosi, Japan      | 118| M   | 133.0       | 0.1        | -3.42    | Vertebral | [24]       |
|                   | 139| F   | 177.0       | 0.07       | -3.29    |          |            |
| Nusa              | 257| M   | 122.0       | 0.1        | -0.01    | Length-frequency | This |
| Tenggara, Indonesia | 327| F   | 130.0       | 0.1        | -0.01    |          | [26]       |
| Indonesia         | 584| C   | 132.0       | 0.1        | -0.01    |          |            |

Note: N: Total Sample; M: Male; F: Female; C: Combined

Due to the large sample size (n=584) and the broad range of sample sizes (56-128 cm TL) obtained in this study, we are confident that the results of this study are able to adequately describe the age and growth of starspotted smooth-hound (M. manazo) in West Nusa Tenggara waters. With the characteristics of slow growth (K=0.1 year⁻¹), like other shark species [28,29], the starspotted smooth-hound population is probably vulnerable to overfishing. Several actions should be conducted in order to maintain the sustainability of this species, but more information is still needed, and it could be obtained by time-series length-frequency monitoring and stock assessment studies.

5. Conclusion

*Mustelus manazo* caught from southern West Nusa Tenggara had growth parameters: male was Lt=122 (1-e⁰.1(t+0.01)), female was Lt=130 (1-e⁰.18(t+0.02)) and combined sex was Lt=132 (1-e⁰.1(t+0.01)). Total mortality was estimated at 0.25 year⁻¹. The results from this study represent basic information to support fisheries management of *M. manazo* in Indonesia.

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7. Acknowledgment

The authors are grateful to the Research Institute for Fish Enhancement and Conservation, Ministry of Marine Affairs and Fisheries Republic of Indonesia for funding this research through the research program titled: "Ecologically Related Species of Sharks and Rays" on Fiscal Year 2016 Budget Year. Each author was a primary contributor for this article. Special thanks to Mr. Galih Rakasiwi for helping as an enumerator and for those who have helped a lot during the data collection of sharks in Tanjung Luar, East Lombok.