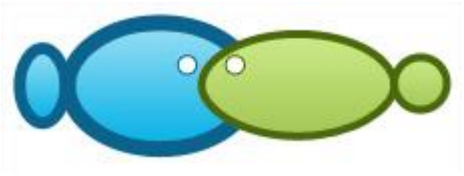

Length-weight relationship and growth parameters of Indonesian houndshark (*Hemitriakis indroyonoi* White, Compagno & Dharmadi, 2009) caught from artisanal fisheries in Southern West Nusa Tenggara Waters

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Abstract. Indonesian houndshark (*Hemitriakis indroyonoi* White, Compagno & Dharmadi, 2009) is a shark species commonly caught in the southern West Nusa Tenggara waters, but its scientific information is limited. This study aimed to assess the length-weight relationship and growth parameters of the Indonesian houndshark, in southern West Nusa Tenggara waters. The research was conducted in Tanjung Luar from January to December 2016 and April and July 2019. The collecting of the data was assisted by an enumerator. The data was analyzed by the analytical method. The results showed that Indonesian houndshark length-weight relationship formula was $W=0{,}0037TL^{2{,}9684}$ ($R^2=0{,}8059$). Its growth pattern was allometric negative, growing in length with higher intensity than in weight, and with a relatively good condition factor. Indonesian houndshark can reach to the asymptotic size of 136.5 cm with a small growth coefficient (K) of 0.27 $years^{-1}$. The slow growth indicated that Indonesian houndshark is vulnerable to overfishing, so it is necessary to regulate the fishing activity.
Key Words: Indonesian houndshark, *Hemitriakis indroyonoi*, growth pattern, growth parameters, length-weight relationship.

Introduction. The southern coastal waters of West Nusa Tenggara, including the Lesser Sunda ecoregion, have a unique landscape in the form of territorial waters that face directly to the Indian Ocean with transitional zones from the litoral region, continental slope and continental shelf to deep-sea waters. The varied and dynamic conditions of its aquatic habitats affect the biodiversity and endemicity of biota in the area (Monk et al 2000; DeVantier et al 2008; Perdanahardja & Lionata 2017). The existence of the Java Trench, which stretches from the south of the western Java Island to the south of Sumbawa Island and Sumba Island, has become a specific habitat for the Indonesian houndshark (*Hemitriakis indroyonoi*). White et al (2009) reported that the shark presumably lives on the outer continental shelf and upper slope, so it is classified as a demersal shark. In Indonesia, this shark is commonly caught by fishermen in the Indian Ocean south of Java, Bali and West Nusa Tenggara by longlines and bottom gill nets to a depth of more than 60 m, because it is a demersal shark (White et al 2006).

Initially, *H. indroyonoi* was considered an endemic shark to the southern Indian Ocean in Indonesia (Dharmadi et al 2009; Faizah et al 2012), but now the shark has been caught and reported in the waters of the Andaman and Nicobar Archipelago in India (Kumar et al 2018; Tyabji et al 2018). The taxonomy of *H. indroyonoi* officially began to be presented since 2009, and previously was identified as *Hemitriakis* sp. The scientific naming of *H. indroyonoi* is a tribute to Dr. Indroyono Soesilo, who is credited with providing support for shark and ray fisheries research (Elasmobranchii) in Indonesia (White et al 2009; Faizah et al 2012; Froese & Pauly 2019). These sharks from the Triakidae family have their local names in some areas, e.g. "hiu kacangan" (Bali), "hiu

meong" (Lombok), "karil" (West Java), and "cucut londer" (Java) (White et al 2006; Faizah et al 2012). Unfortunately, the information regarding *H. indroyonoi* in Indonesia is still limited because this shark is not a targeted species and is a by-catch in fishing activities from fishing ports in Tanjung Luar, Kedonganan and Muncar (Nurcahyo et al 2016; Sentosa & Dharmadi 2017; Caesar et al 2018; Zulfiaty et al 2018). The scientific data which is available in Indonesia regards the description of the species (White et al 2009), some common biological parameters in Fishbase (Froese & Pauly 2019; White 2007) and the article from Faizah et al (2012) which had discussed its reproductive biology.

The data and information related to *H. indroyonoi* is needed for the basic management and conservation efforts (Sadili et al 2015). Nevertheless, the data is lacking. Similar to other sharks, the biological characteristics of this species are susceptible to overfishing pressure, so they tend to be vulnerable to extinction (Castro et al 1999; Stobutzki et al 2002; Gallucci et al 2006; Fahmi & Dharmadi 2013).

One information needed in the management and conservation of sharks is the length-weight relationship, the value of the asymptote length (L_∞) and the growth coefficient (K) (Sparre & Venema 1998; Effendie 2002; King 2007). This study aimed to estimate the length-weight relationship and growth parameters of Indonesian Houndshark (*Hemitriakis indroyonoi*), caught in artisanal fisheries from Southern West Nusa Tenggara Waters. The length-weight relationship and growth parameters are useful in fishery management and conservation for both primary and applied usage. They are essential to convert length-frequency data into accurate biomass estimates and are often used in stock assessment (King 2007; Güven et al 2012; Silva et al 2013).

Material and Method

Data collection method. This study was carried out in artisanal fisheries in Tanjung Luar Fish Landing Port, East Lombok, West Nusa Tenggara (Figure 1). According to information from the fishermen, the Indonesian houndshark (*H. indroyonoi*) is commonly caught in southern West Nusa Tenggara waters by bottom longlines. The data was collected by measuring the total length (TL) and body weight (W) of the Indonesian houndshark (*H. indroyonoi*) from January to December 2016 and continued in April and July 2019 with the assistance of a trained enumerator. Identification of *H. indroyonoi* was carried out according to White et al (2006) and White et al (2009).

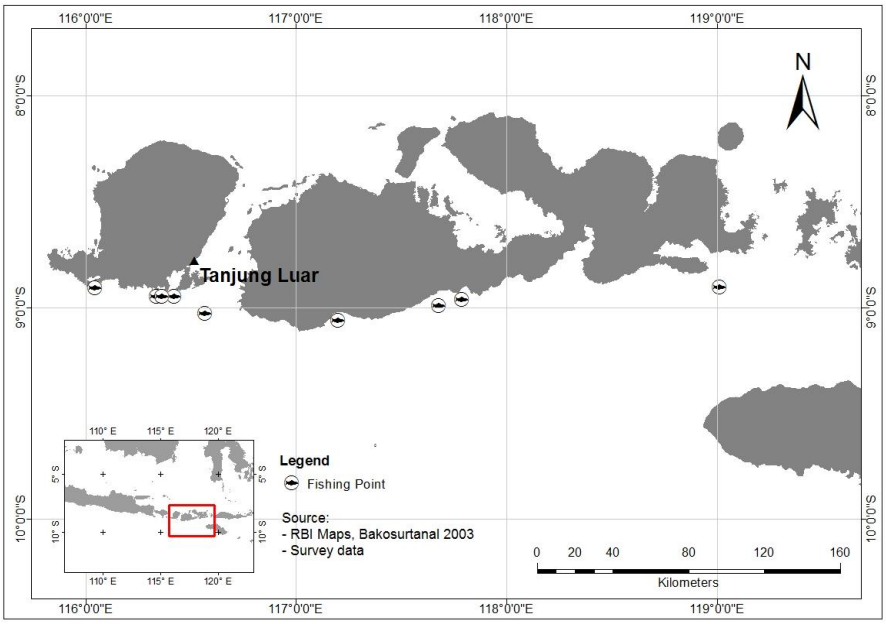

Figure 1. Sampling site at Tanjung Luar Fish Landing Site, East Lombok (▲).

Data analysis. The relationship between total length and body weight was analyzed by the power curve formula:

$$W=aL^b$$

where W is body weight in grams, L is the total length in cm, a and b are constants (Effendie 2002; Güven et al 2012). The values of a and b are estimated through linear regression analysis using the transformed equation by natural logarithms as (King 2007):

$$\ln[W]=\ln[a]+b*\ln[L]$$

The growth pattern tested for its accuracy to the value of b=3 using the t-test with a confidence level of 95% (King 2007; Motta et al 2014).

The condition factor for assessing the well-being condition is analyzed using the relative condition factor (Cn) based on the formula:

$$Cn = \frac{W}{W'}$$

where Cn is a relative condition factor, W is the observed body weight, and W' is a predicted body weight based on the method of the length-weight relationship (Effendie 2002; King 2007; Jisr et al 2018).

The growth parameters in the von Bertalanffy growth model is useful for estimating length and age (Sparre & Venema 1998). The asymptote length (L_∞) and growth coefficient (K) is calculated using the Shepherd method, which maximizes the non-parametric values of the von Bertalanffy growth model. All calculation is available in FiSAT II software package (Gayanilo et al 2005). The theoretical age (t_o) is predicted by the empirical equation of Pauly (Pauly 1983).

Results. A total of 454 Indonesian houndsharks, were caught and measured from the southern waters of West Nusa Tenggara. Length-weight measurements obtained in range, average, and standard deviation values were 25-129 cm (87.6±13.16 cm) and 0.2-7.6 kg (2.4±1.039 kg). The length distribution was shown in Figure 2.

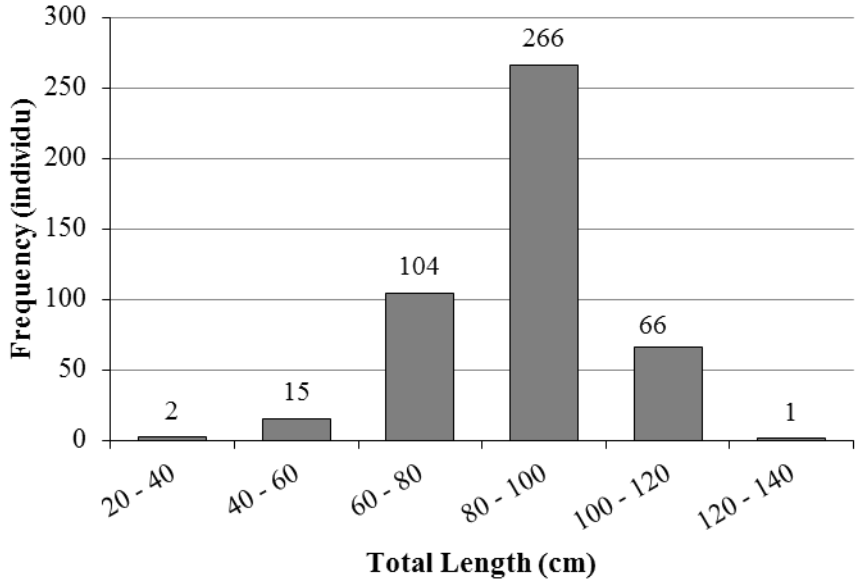

Figure 2. Total length distribution of Indonesian houndshark in southern West Nusa Tenggara.

By calculating the length-weight relationship, the L-W model for *H. indroyonoi* was formulated as $W=0.0037*TL^{2.9684}$ ($R^2=0.8059$). The t-test value of b against value 3

showed the value of b≠3 or b<3 so that the growth pattern of the Indonesian houndshark was allometric negative (P<0.05), which means that they grow with higher intensity in length than in weight. The correlation value and the coefficient of determination for the length-weight relationship are 0.8977 and 80.59%, respectively. It showed that there was a close relationship between length and weight variables, and the total length had an influence on body weight (Figure 3).

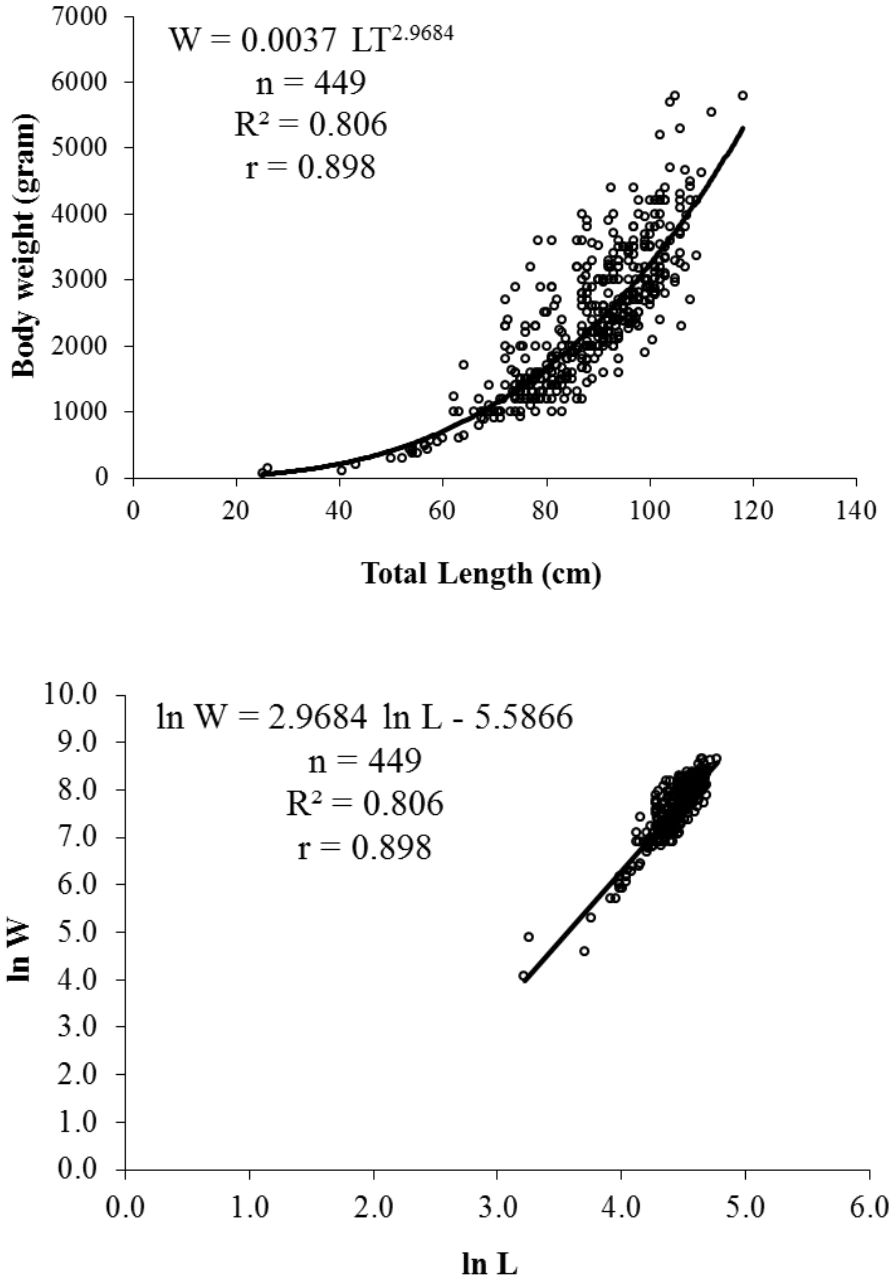

Figure 3. Length-weight relationships of Indonesian houndshark in southern West Nusa Tenggara.

The relative condition factor value (Cn) of Indonesian houndshark during the study varied within a range between 0.452-2.279, with a mean Cn value of 1.034±0.288 (Figure 4). The mean of Cn was also relatively close to value 1, so it could be said that the condition of the Indonesian houndshark, in general, was relatively in well-being condition, where the ratio between actual weight and predicted weight is almost equal.

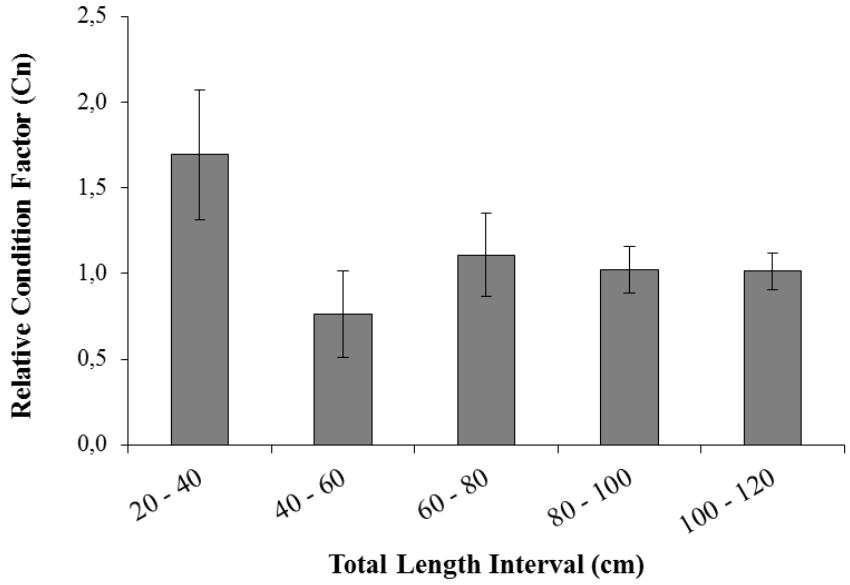

Figure 4. The relative condition factor value (Cn) of Indonesian houndshark during the study.

The growth parameters of the Indonesian houndshark showed an asymptote length (L_∞) of 136.5 cm with a growth coefficient (K) of 0.27 years^{-1}, and the theoretical age (t_0) at a null length was -0.41 years (Figure 5). According to von Bertalanffy modeling, the curve equation is defined as L(t)=136.5*[1–exp(-0.27(t-(-0.41)))] or $L(t) = 136*(1–e^{(-0.27(t-(-0.41))})$. The curve showed that *H. indroyonoi* could reach its estimated asymptote length value at the age of about 30 years (Figure 5).

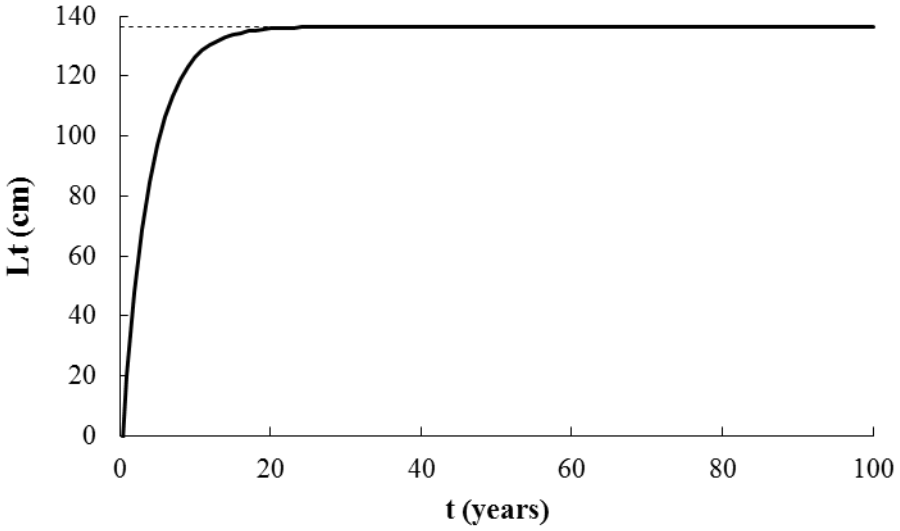

Figure 5. Growth curve of Indonesian houndshark in southern West Nusa Tenggara.

Discussion. The information about *H. indroyonoi* in Indonesia is still limited because it is not a targeted species in artisanal fisheries in Tanjung Luar. Previously, this species was considered an endemic shark to Indonesia (White et al 2006), but now it had been reported in the waters of Campbell Bay in Andaman and Nicobar Islands (Tyabji et al 2018), so its status is no longer endemic to Indonesia. This demersal shark is commonly caught by bottom longlines, which are set at depths of 50-100 m. The fishing areas for the bottom longlines are around southern Nusa Tenggara waters (White et al 2012). Because of the lack of information, we assumed that the depth range of the Indonesian houndshark was the same as the depth setting of bottom longlines, of 50-100 m,

although that still requires further study for robust evidence. White et al (2009) reported that *H. indroyonoi* was typically caught along with squalid dogsharks (Squalus), so they presumably occur on the outer continental shelf and the upper slope. The comparison between the Indonesian houndshark in this study and the other congener sharks are shown in Table 1.

Table 1

The comparison between the Indonesian houndshark in this study and congener sharks

Species	*Depth range (m)*	*Maximum Total Length (cm)*	*References*
H. indroyonoi	50 to 100 m	128 cm	This study
H. abdita	225 to 400 m	-	(White 2016)
H. complicofasciata	90 to 100 m	96 cm	(Nakaya 2009)
H. falcata	110 to 200 m	80 cm	(Kyne & Cavanagh 2016)
H. japanica	> 100 m depth	120 cm	(White 2009)
H. leucoperiptera	to a depth of 48 m	96 cm	(Compagno 2006)

The size of the Indonesian houndshark caught in this study was generally greater than that of White et al (2006) and White (2007), who reported the shark only reached a length of up to 120 cm. The maximum length of the captured sharks is 128 cm, with an asymptote length capable of reaching 136.5 cm. When compared with congener sharks, the maximum length of *H. indroyonoi* is the largest ever reported (Table 1). Sentosa & Dharmadi (2017) reported that the relative abundance of the Indonesian houndshark was 0.61% from the total catch landed in Tanjung Luar. The fishing effort with bottom longlines in southern Nusa Tenggara had provided a higher probability of catching this shark in various sizes (White et al 2012). The average catch size is also relatively similar to the results of the study of Faizah et al (2012) in the same fishing ground south of Bali and Nusa Tenggara. White et al (2006) stated that male sharks matured at 92–95 cm and females at about 100 cm. Meanwhile, White (2007) reported that the male sharks matured at 88.3-91.2 cm. According to this information, the average length size of *H. indroyonoi* (87.6 ± 13.16 cm) indicated that the catch in southern Nusa Tenggara was still common in the juvenile stage. The Indonesian houndshark is vulnerable to extinction if this shark will be overfished continuously, especially if the catch is still immature.

The length-weight relationships of the Indonesian houndshark, provided from this study, could be useful for fisheries officers or other stakeholders to estimate the biomass or bodyweight from the total length (Froese 2006; Motta et al 2014). Previously, regarding this shark, there was little or no information on its length-weight relationships, both in FishBase (Froese & Pauly 2019) and other reports. Given that in artisanal fisheries from Tanjung Luar the sharks are processed (beheaded, eviscerated and definned) only after landing (White et al 2012; Fahmi & Dharmadi 2013), the length-weight relationships reported here are useful for assessing and monitoring this shark species in coastal areas, especially in southern Nusa Tenggara waters.

The growth pattern of the Indonesian houndshark in this study is negative allometric (b=2.97) and relatively similar to Indonesian houndshark males in a previous study in the same location (Faizah et al 2012). In that study, Indonesian houndshark females had a positive allometric growth pattern, which means that they grow with higher intensity in weight than in length. This result was associated with the used sample and the time difference of the survey. We used a sample of 449 individuals of the combined sex, while Faizah et al (2009) only used a sample of 60 males and 54 females. Because of more samples, we are more accurate in predicting the length-weight relationships for combined sexes of *H. indroyonoi*. The different research times will also affect the value of b due to different environmental conditions. According to Stevens & Wiley (1985), variations between length-weight relationships may be a result of different sample sizes and an unequal distribution of sizes within each data set. The relative condition factor of Indonesian houndshark in the current study ranged between 0.452-2.279 with a mean Cn value of 1.034±0.288. These values suggest a state of well-being

for this species. According to Jisr et al (2018), the deviation of Cn from 1 reveals information concerning the differences in food availability and the consequence of physicochemical features on the life cycle of fish species. In this study, we did not assess the habitat condition in southern Nusa Tenggara waters, but we supposed that the habitat, environmental factors, and availability of food affected the value of the condition index (Morato et al 2001).

The growth coefficient of Indonesian houndshark also shows a slow growth rate of 0.27 $years^{-1}$. Until this study, we did not find information about age and growth parameters of Indonesian houndshark and the other congener houndshark (*Hemitriakis* spp.). However, if it is compared to other Triakidae sharks such as *Mustelus manazo*, which had an estimated growth coefficient range from 0.22 to 0.53 $years^{-1}$ for males and 0.21 to 0.36 $years^{-1}$ for females (Francis 1981), the growth rate of *H. indroyonoi* was almost the same as *Mustelus manazo*, which had a slow growth rate. This condition shows some characteristics of sharks such as a long life cycle and slow growth rate (Castro et al 1999; Compagno 1998; Last & Stevens 1994; Stobutzki et al 2002). Through the von Bertalanffy growth rate equation, the Indonesian houndshark in the southern West Nusa Tenggara waters is theoretically able to reach its asymptotic length after 30 years. If this shark is caught continuously even as a by-catch, it is probable that its population would decline.

Although the Indonesian houndshark is regularly caught by bottom longlines, it is a by-catch fish for fishermen. Its utilization is limited for its meat and fins but only for the local market due to its size (White et al 2006). Almost the same as for other species of sharks, the body parts that could be used generally were the flesh and fins (Dharmadi et al 2015; Fahmi 2010). In general, sharks are very vulnerable to overfishing pressure (Galluccci et al 2006; Musick et al 2000). Therefore, further research and monitoring of the status of Indonesian houndshark population as one of the native sharks in Indonesia is required as support for sustainable shark fisheries management efforts (Fahmi & Dharmadi 2013; Sadili et al 2015).

Conclusions. Indonesian houndshark (*H. indroyonoi*), as one of the shark species caught in the southern West Nusa Tenggara waters, has the following length-weight relationship equation: $W=0{,}0037TL^{2{,}9684}$. Its growth pattern is negative allometric, meaning that they grow with higher intensity in length than in weight. The Indonesian houndshark can presumably grow up to 136.5 cm in length, with a growth rate constant of 0.27 $years^{-1}$. Further research is needed on the status of Indonesian shark populations so that data and information can support shark fisheries management and conservation strategies. However, the information gained in the present survey can enable fish biologists to derive weight estimates for Indonesian houndshark caught from the southern Nusa Tenggara waters and that are measured in length, but not weighed. The length-weight parameters as a result of this report may be of considerable use in ongoing studies of Indonesian houndshark catches in artisanal fisheries in Tanjung Luar.

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