E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2018; 6(4): 36-41

www.fisheriesjournal.com
Received: 24-05-2018
Accepted: 26-06-2018

Yoppy Jutan
Marine Science Post Graduate Program, Pattimura University, Ambon

ASW Retraubun
Department of Aquatic Resource Management, Faculty of Fishery and Marine Science Pattimura University, Ambon

AS Khouw
Department of Aquatic Resource Management, Faculty of Fishery and Marine Science Pattimura University, Ambon

VPH Nikijuluw
Marine Conservation International Indonesia

JA Pattikawa
Department of Aquatic Resource Management, Faculty of Fishery and Marine Science Pattimura University, Ambon

Correspondence
Yoppy Jutan
Marine Science Post Graduate Program, Pattimura University, Ambon

Study on the population of Halmahera walking shark *(Hemiscyllium halmahera)* in kao bay, north maluku, Indonesia

Yoppy Jutan, ASW Retraubun, AS Khouw, VPH Nikijuluw and JA Pattikawa

Abstract
Halmahera walking shark (*Hemiscyllium Halmahera*) is an endemic species that only found in Halmahera Islands, Indonesia at shallow waters on coral reef. The research to study population of Halmahera walking shark was conducted in Kao bay, North Maluku on March 2017 to February 2018. Samples collected during night dive were measured and analysed by using FiSAT program. Totally, 604 individuals of Halmahera walking shark were collected during the study with the total length ranging from 16.9-79.0 cm. The von Bertalanffy growth function for this species is $L_t = 81.25\ [1–e^{-0.51(t+0.24)}]$. Recruitment occurred all year round with the major peak between July and September. Mortality rates of Halmahera walking shark were 1.89, 0.90 and 0.99 for total, natural and fishing mortalities, respectively with exploitation rate was 0.52. The values of E max, E 0.50 and E 0.10 estimated by yield per recruit method were 0.375, 0.245 and 0.307, respectively. As current exploitation ratio, E=0.52 > EMSY=0.245, it seems that population of walking shark in this area is over-exploited

Keywords: Halmahera walking shark, growth, mortality, exploitation rate

1. Introduction
Shark fins are the most expensive seafood item in the world. In the last few decades, demand of shark fins are increasing to fulfill people consumption in East and Southeast Asia countries such as China, Taiwan, Singapore, Malaysia and Vietnam. The capture production of shark has been triplet in 2000 compared to the production in 1950 [1]. However, recent trend shows that the production of shark has been declined and the greatest decline occur in Western Central Pacific and Western Indian Ocean [2]. This decline occurs partly due to increase of fishing effort, pollution, habitat degradation, climate change and intrinsic vulnerability of sharks [1].
Walking sharks, *Hemiscyllium* spp are composed of nine species belong to the family of Hemiscylliidae. Member of this family is well known as epaulette or bamboo sharks which occupy restricted area of coral reef at shallow waters [3]. These reef sharks are particularly vulnerable to overfishing due to their territorial habits, late onset of sexual maturity, low fecundity, and slow growth rates [4].
One of the members of family Hemiscylliidae is Halmahera walking shark (*Hemiscyllium halmahera*) or locally known as *gorango bodoh*, *gorango buta* or *gorango loreng* which is an endemic species from Halmahera islands. This shark is nocturnal species, active during the night and hiding between the reef during the day. Halmahera walking shark has slow movement, walking at the bottom by pushing itself using pectoral and dorsal fins, so it is easily found during night dive. Sometimes, fishers in the area catch this shark to consume its meat or to sell a young living one as aquarium pet.
Information about Halmahera walking shark (*H. halmahera*) is limited. The only information based on two specimen reported by Allen *et al.* (2013) [3] and Allen *et al.* (2016) [5]. Therefore, this research was conducted to study population of Halmahera walking shark by focusing on length distribution, growth, mortality, exploitaion rate and yield per recruit.

2. Materials and Methods
2.1. Study area
This research was conducted in Kao bay, Halmahera islands, North Maluku, Indonesia on

March 2017 to February 2018. Four locations were chosen randomly as sampling sites: 1°15'45.17"N 128°3'2.16"E, 1°18'47.38"N 128°3'25.09"E, 1°16'40.26"N 128°2'11.17"E, 1°18'17.61"N 128°5'10.68"E (Figure 1).

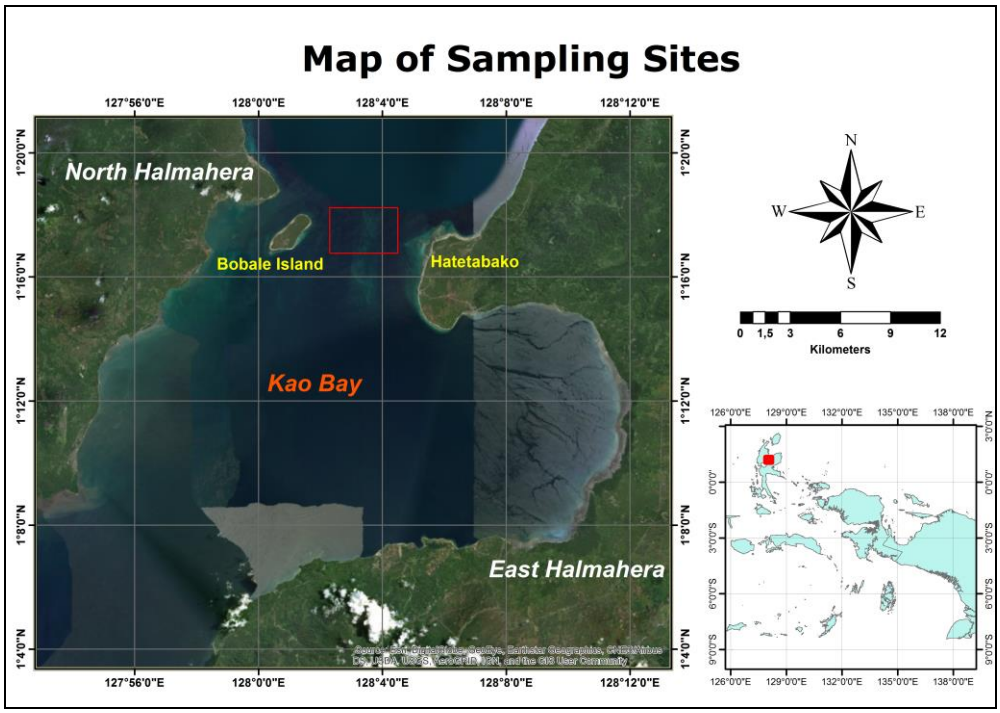

Fig 1: Map of sampling sites (red square)

2.2. Data Collection

Sample of walking shark was collected during night dive by using using plot method. Totally, there were 296 night dives at 19.30-21.30 pm, 22.00-24.00 pm, 01.00-03.00 am and 03.00-05.00 am. Total length of walking shark collected was measured from the tip of the mouth to the tip of the tail to the nearest 0.1 cm by using a 100 cm plastic rules and then weighted by using a 5.0 kg portable digital balance to the nearest g. Length and weight data were tabulated by using Microsoft Excel 2016.

2.3. Data Analysis

The von Bertalanffy Growth Function (VBGF) fitted in FiSAT II software [6] was used to estimate the growth parameters: growth rate (K) and asymptotic length (L∞) following the Powell–Wetherall method [7]. This method was used to estimate initial value of L∞ and then using this value to determine the value of K. Adjustments was made to get the best combination of both values to maximize the goodness of fit (Rn) criterion. The third parameter in VBGF, t_o (theoretical age at birth) was calculated independently, using the empirical formula [8]: $\log_{10}(-t_o) = -0.3922 - 0.275 * \log_{10}L\infty - 1.038 * \log_{10}K$

The instantaneous rate of total mortality (Z) was estimated by constructing linearized length-converted catch curves incorporated in the FiSAT II tool. Instantaneous natural mortality rate (M) were computed using the empirical equation with a mean annual surface temperature (T) of 30° C: $Log_{10}M = - 0.0066 - 0.279\ 1og_{10}\ L\infty + 0.6543\ log_{10}\ K + 0.4634\ log_{10}\ T$, where L∞ and K are growth parameters of the VBGF [8]. Fishing mortality was calculated using the relationship: F = Z – M [8].

The recruitment pattern was determined using FiSAT tool to estimate the number of pulses per year and the relative strength of each pulse by reconstructing the recruitment pulse from a time series of length–frequency data with input parameters included L∞ and K.

The relative yield per recruit was computed using Knife-edge option following the procedure incorporated in the FiSAT II tool.

3. Results and Ddiscussion

3.1. Length Distribution

Totally, there were 604 individuals of walking shark (*H. halmahera*) collected during 296 night dives between March 2017 and February 2018 in Kao bay, North Maluku. Total length (TL) of walking shark collected ranging from 16.9 cm to 79.0 cm with the mean was 56.66 cm.

Bamboo sharks of the genus *Hemiscyllium* usually have small size i.e. less than 85 cm TL [5]. However, Last and Stevens (2009) [9] reported the largest size of *Hemiscyllium ocellatum* i.e. 107.0 cm TL in Australian waters, while Janson *et al*. (2012) [10] and Allen *et al*. (2016) [5] reported 84.0 cm TL and 65.7 cm TL, respectively for the same species. On the contrary, Allen *et al*. (2016) [5] reported the largest size so far for this genus belongs to *Hemiscyllium henryi* from Triton Bay, West Papua, Indonesia, i.e. 81.5 cm TL. Two specimens of Halmahera walking shark (*H. halmahera*) reported by Allen *et al*. (2013) [3] from Halmahera islands were 65.6 cm and 68.1 cm TL for female and male respectively.

Length frequency distribution of Halmahera walking shark (*H. halmahera*) presented in Figure 2 showed that total length class 55.0 – 75.0 cm dominated the size of fish samples collected. There is no information available on length frequency distribution of bamboo shark genus *Hemiscyllium.* The only available information so far is for genus Chiloscyllium namely Whitespotted Bamboo Shark, *Chiloscyllium plagiosum* reported by Chen *et al*. (2007) [11] which has similar length distribution with Halmahera walking shark (*H. halmahera*).

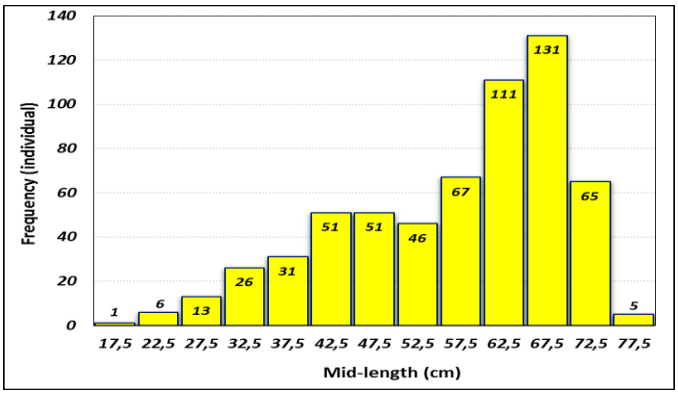

Fig 2: Length frequency distribution of *Hemiscyllium Halmahera*

3.2. Growth

Figure 3 shows length frequency distribution with the superimposed growth curve output for the twelve successive months between March 2017 and February 2018 from the FiSAT analysis. Estimated asymptotic length (L∞**)** was 81.25 cm TL and the combination of this value with various values of annual growth rate (K) give the maximum goodness of fit, Rn=0.286 for the K = 0.51 per year. Estimated theoretical age of birth t_0 was -0.24, hence the von Bertalanffy Growth Function for Halmahera walking shark (*H. halmahera*) from Kao bay, Halmahera was $L_t = 81.25\ (1- e^{-0.51(t + 0,24)})$. Growth curve which is represented length of Halmahera walking shark at various ages is shown in Figure 4.

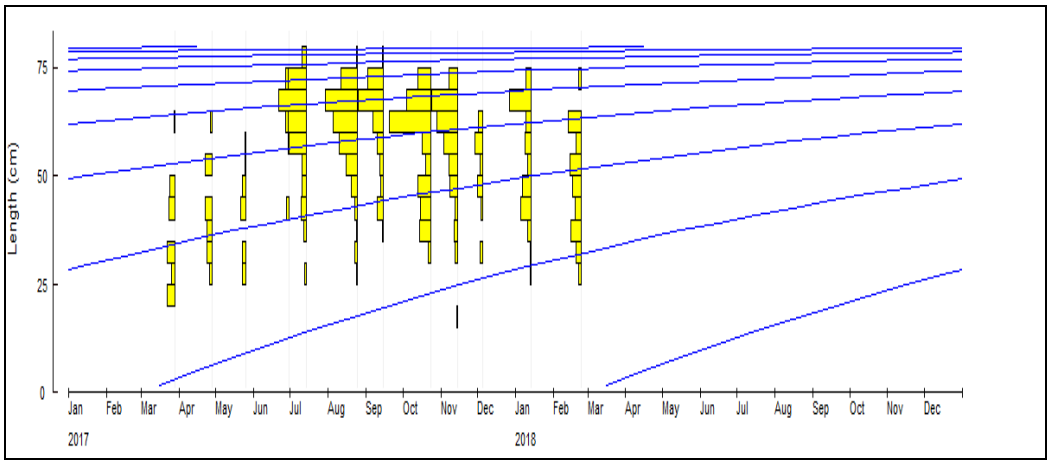

Fig 3: FiSAT output of length frequency distribution with superimposed growth curve of *Hemiscyllium Halmahera*

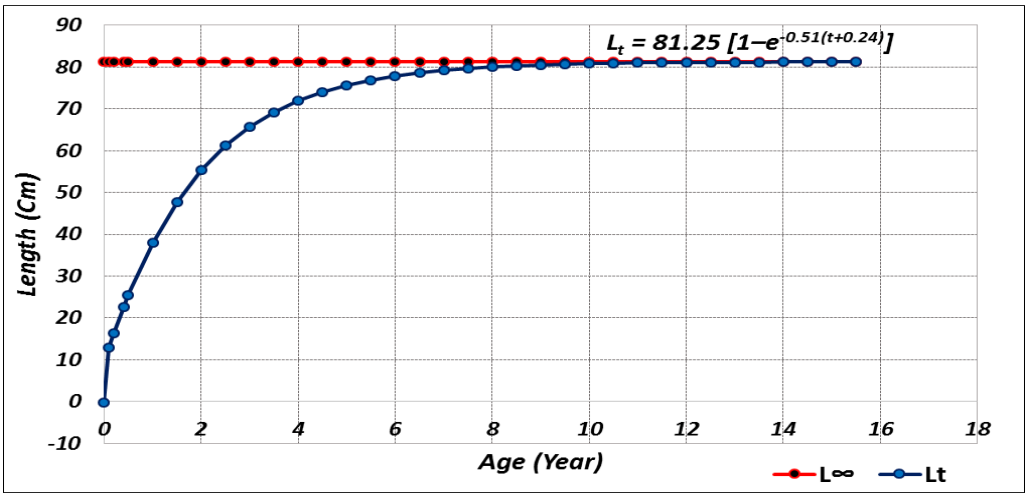

Fig 4: Growth curve of *Hemiscyllium halmahera*

This result indicated that maximum length (79.0 cm TL) of Halmahera walking shark (*H. halmahera*) from Kao bay, Halmahera can be achieved in about seven years, but 50% of its asymptotic length will be attained in less than two years. These figures implied that *H. halmahera* is fast growing species at younger ages before reaching it get mature in at the age of about two to three years. Pauly (1983) [8] stated that before maturation, young fish grows faster because most of the energy from food is converted for growth. According to Kienzle (2005) [12] growth coefficient between 0.34 and 0.67 per year are mostly intermediate growing species, while Branstetter (1987) [13] stated that growth coefficient from 0.2 – 0.5 per year can be categorised as rapid growth. Based on those criterion, Halmahera walking shark (*H. halmahera*) from Kao bay, Halmahera can be considered as intermediate to fast growing fish species.

3.3. Recruitment Pattern

Recruitment pattern of Halmahera walking shark (*H. halmahera*) is presented in Figure 5. Recruitment of this walking shark occurs all year round at different strength with two peaks, minor peak occurs in March and mayor peak in July to September. The lowest relative recruitment occurred in April (2.88%) while the highest found in July (15.40%)

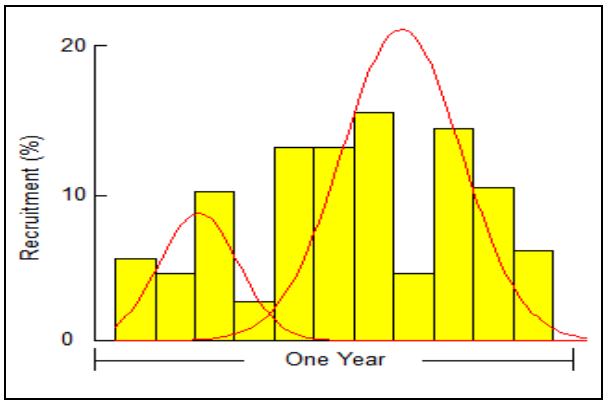

Fig 5: Recruitment of *Hemiscyllium halmahera*

Totally, there were 20 individuals of young Halmahera walking shark (*H. halmahera*) found during the study with their size < 30 cm TL. Two of those juveniles at sizes of 16.9 cm and 26.0 cm TL is shown in Figure 6. Based on video, member of genus *Hemiscyllium*, young *H. ocellatum* emerge from egg at 15 cm TL after incubation for 130 days at Tennessee Aquarium [5]. Furthermore the authors [5] stated this young shark reach a size of about 20 cm TL after 4 months, about 30 cm TL after 12–18 months, and about 45–51 cm TL after two years. Based on this information and the result of estimated growth parameter, the age of two young individuals of Halmahera walking shark (*H. halmahera*) found in Kao bay are predicted at 6 -12 month old.

Fig 6: Juvenile of *Hemiscyllium halmahera* collected in November 2017, 16.9 cm TL (left) and in January 2018, 26.0 cm TL (right)

There were 60 individuals mature female found during the research with 8 – 12 eggs. However, based on observation in the laboratory only two eggs were deposited at the bottom of the aquaria from one individual female (62.8 cm TL, about 3 year old) (see Figure 7).

Fig 7: Young eggs (left) and two eggs capsules (right) of *Hemiscyllium halmahera*

3.4. Mortality and Exploitation Rate

Linearized length-converted catch curves in Figure 8 showed that estimated total mortality rate (Z) of *H. halmahera* was 1.89 yr^{-1}. Estimated natural mortality rate (M) for this species by using empirical formula [8] with annual temperature T = 30° C was 0.90 yr^{-1} while the value of fishing mortality (F) was 0.99 yr^{-1}. By comparing fishing mortality rate and total mortality rate, exploitation rate (E) for this species in the area was estimated at 0.52.

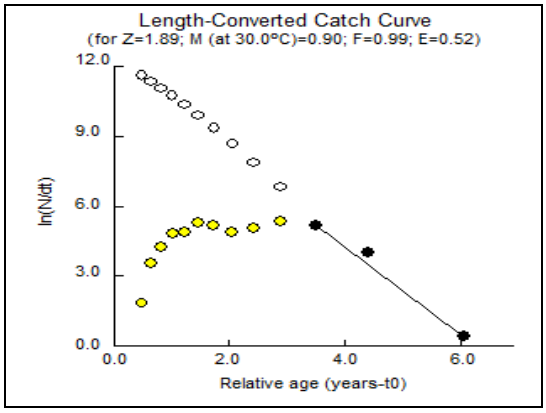

Fig 8: Linearized length-converted catch curves of *Hemiscyllium halmahera*

Walking sharks of the genus *Hemiscyllium* can survive at bad condition. However, they are vulnerable because of their restricted habitat at shallow waters. Human impact that cause pollution and habitat degradation as well as climate change can have severe impact on population of walking sharks [1]. In addition, reproduction mode of this species, i.e. only two eggs are deposited on the bottom substrate and need long time to hatching (more than 4 months) make Halmahera walking shark become more vulnerable. Furthermore, unfriendly fishing practices in the area such as the use of explosive and cyanide as well as gold mining activity can affect the population of Halmahera walking shark. Decreasing of walking shark, *H. michaeli* population due to habitat degradation had been reported occurred in Milne bay, New Guinea [14].

3.5. Relative Yield per Recruit

The result of yield per recruit analysis of Halmahera walking shark (*H. halmahera*) used Lc/L∞ dan M/K as input parameters in which Lc = 72.42 cm (Figure 9).

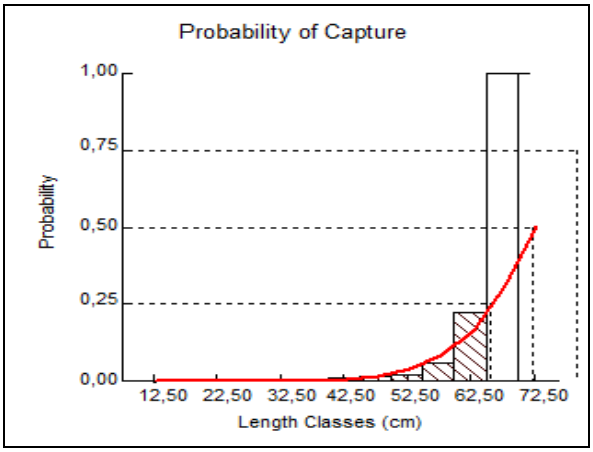

Fig 9: FiSAT output for probability of capture of *Hemiscyllium halmahera*

It can be seen in Figure 10 that the E max, E 0.50 and E 0.10 values estimated by the relative yield per recruit analysis were 0.375, 0.245 and 0.307, respectively. Current exploitation ratio of Halmahera walking shark (*H. halmahera*) based on mortalities rate, E=0.52 is far higher than E max and E MSY based on relative yield per recruit analysis. These figures indicated that the population of Halmahera walking shark (*H. halmahera*) in Kao bay is over-exploited.

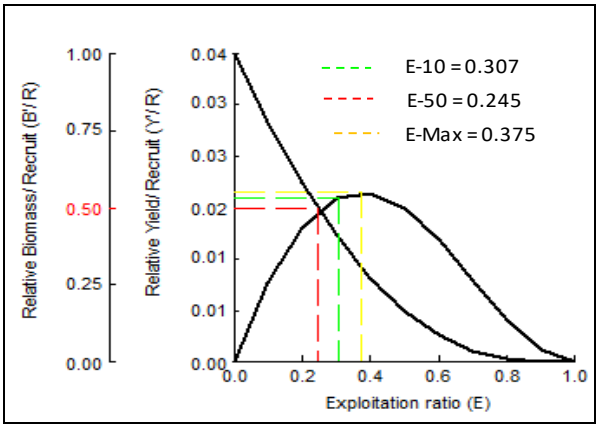

Fig 10: Relative yield per recruit curve of *Hemiscyllium halmahera*

Halmahera walking shark (*H. halmahera*) is not the main target species in this area. However, fishers in Kao bay often catch an adult fish for its meal and juvenile one for aquarium pet. In addition, unfriendly fishing practices as well as destruction of habitat because of mining activities make this species become vulnerable.

4. Conclusion

A total of 604 individuals of Halmahera walking shark (*H. halmahera*) were collected with total length between 16.9 cm and 79.0 cm and the mean was 56.66 cm. The von Bertalanffy growth function for this species was $L_t = 81.25\ [1–e^{-0.51(t+0.24)}]$. There were two recruitment peaks with the major peak occurred between July and September. Mortality rates of Halmahera walking shark were 1.89, 0.90 and 0.99 for total, natural and fishing mortalities, respectively with exploitation rate was 0.52. This exploitation rate is higher than E50 (EMSY) of yield per recruit which indicated that Halmahera walking shark (*H. halmahera*) in Kao bay is over-exploited.

5. Acknowledgements

The authors would like to thank the government of North Halmahera Regency for financial supporting through doctoral scholarship program to Yoppy Jutan. We also thank David Soumokil, Gidion Manabung and fishers group Cinta Bahari of Tobelo District, North Halmahera Regency for their assistance in data collection.

6. References

1. Marshall JL, Barone M. *SharkFin Guide*: Identifying Sharks From Their Fins. Food and Agriculture Organization of the United Nations Rome, 2016, 144.
2. Davidson LNK, Krawchuk MA, Dulvy NK. Why have global shark and ray landings declined: improved management or overfishing? Fish and Fisheries, 2015. doi: 10.1111/faf.12119.
3. Allen GR, Erdmann MV, Dudgeon CL. *Hemiscyllium halmahera*, a new species of Bamboo Shark (Hemiscy lliidae) from Indonesia. Aqua, International Journal. 2013; 19(3):123-136.
4. Allen GR, Erdmann MV. Reef fishes of the East Indies. Vol. I-III, Tropical Reef Research, Perth, Australia in cooperation with Conservation International, Indonesia Marine Program, Denpasar Indonesia. 2012, 1292.
5. Allen GR, Erdmann MV, White WT, Fahmi, Dudgeon CL. Review of the bamboo shark genus *Hemiscyllium* (Orectolobiformes: Hemiscyllidae). Journal of the Ocean Science Foundation. 2016; 23:51-97.
6. Gayanilo FC, Sparre P, Pauly D. The FAO-ICLARM Stock Assessment Tools (FiSAT) User's Guide. FAO, Rome, 2003, 176.
7. Wetherall JA, Polovina JJ, Ralston S. Estimating growth and mortality in steady-state fish stocks from length-frequency data. In: Length-based methods in fisheries research. Pauly D., Morgan G.R. (Eds), ICLARM Conference Proceedings, 1987; 13:53-74.
8. Pauly D. Some Simple methods for the assessment of tropical fish Stock. FAO Fisheries Technical Paper. 1983; 234:52.
9. Last PR, Stevens JD. Sharks and rays of Australia. Collingwood, Vic: CSIRO Pub, 2009, 644.
10. Janson MW, Wueringer BE, Seymour JE. Electroreceptive and mechanoreceptive anatomical specialisations in the epaulette shark (*Hemiscyllium ocellatum*). PLoS One journal. 2012; 7(11):e49857.

Tenth Anniversary Published online, 2012, 30.
11. Chen WK, Chen PC, Liu KM, Wang SB. Age and growth estimates of the whitespotted bamboo shark, *Chiloscyllium plagiosum*, in the Northern Waters of Taiwan. Zoological Studies. 2007; 46(1):92-102.
12. Kienzle M. Estimation of the population parameters of the Von Bertalanffy Growth Function for the main commercial species of the north sea. Fisheries Research Services Internal Report. No. 05/05. Aberdeen, 2005, 34.
13. Branstetter S. Age, growth and reproductive biology of the silky shark, *Carcharhinus falciformis*, and the scalloped hammerhead, *Sphyrna lewini*, from the northwestern Gulf of Mexico. Environ. Biol. Fish. 1987; 19:161-173.
14. Allen GR, Dudgeon CL. *Hemiscyllium michaeli*, a new species of Bamboo Shark (Hemiscyllidae) from Papua New Guinea. Aqua. 2010; 16:19-30.