Received: 28 August 2013

SIZE DISTRIBUTION AND SEX RATIO OF SCALLOPED HAMMERHEAD SHARKS (*Sphyrna lewini*) IN INDIAN OCEAN AT SOUTHERN PART OF JAVA AND NUSA TENGGARA, INDONESIA

Duranta D. Kembaren, Umi Chodrijah and Ali Suman

Research Institute for Marine Fisheries (RIMF), Muara Baru – Jakarta 14440

ABSTRACT

Hammerhead shark is one of the most common shark species in the tropics. The sharks were caught by longline and drift gill nets either bycatch or target catch. Research on the length frequency and sex ratio of scalloped hammerhead shark (*Sphyrna lewini*) was conducted at two shark landing sites in the southern of Java in 2010, namely Oceanic Fishing Port of Cilacap and Fish Landing Site Tanjung Luar, East Lombok, West Nusa Tenggara. Data were collected from the surveyed areas including the length of frequency and the sex composition. The research objective was to obtain data and information for management and conservation of scalloped hammerhead sharks. The results showed that the size distribution of scalloped hammerhead sharks females and males were between 51 cm to 300 cm TL and 127 cm to 244 cm TL, respectively. Sex ratio of male and female were unequal, where female caught more frequent than male. The catch during the study was dominated by the immature fishes. This condition remind that sharks resources should be managed wisely for their sustainability.

Key words : size distribution, sex ratio, scalloped-hammerhead shark, Indian Ocean

INTRODUCTION

Hammerhead shark is one of the most common shark species in the tropics. The sharks are caught by long-line and drift gill nets as both a by-catch and target species. Hammerhead sharks are included in the order of Carcharhiniformes, the family of Sphyrnidae and belongs to the class of Elasmobranchii, which consists of four species, i.e. *Sphyrna lewini, Sphyrna mokarran, Sphyrna zygaena, and Eusphyra blochii.* The most common of hammerhead shark in the Indonesian waters, especially in the Indian Ocean of South Java waters is the scalloped hammerhead shark (*Sphyrna lewini*). The scalloped hammerhead shark has several local names in Indonesia, i.e. '*hiu caping*"/shark hat (Java), "*hiu capil*" (Bali), and "*hiu bingkoh*" (Lombok).

The morphology of scalloped hammerhead sharks were widened head to the side. Its width was less than a third of its body length, the front edge of the head were very curved shallow indentation in the middle, high first dorsal fin somewhat tapered curved, second dorsal fin with a short rear end length and the edges were slightly concave, the hole in the top of the crescent was shaped base of the tail. The reproductive biology of Sphyrnidae is viviparous, with a yolk-sac placenta, give birth to a litters of 12-41 pups after a gestation of 9 to 10 months (White *et al*., 2006). This species is coastal pelagic, semi oceanic, warm temperate and tropical species occurring over continental and insular shelves and in deep water adjacent to them, often approaching close inshore and entering enclosed bay and estuaries. It ranges from intertidal and surface down to at least 275 m depth (Compagno 1999; White *et al.*, 2006).

This paper presents data and information on the size distribution of the scalloped hammerhead which caught from the Indian Ocean waters of Southern Java and West Nusa Tenggara, and also provides some biological information, such as sex ratio, length at maturity and litter size. Conservation status of this species also discussed.

MATERIALS AND METHODS

The study was carried out on February, March, June, August, October and December in 2010 at the two fish landing sites, namely Oceanic Fishing Port of Cilacap and Fish Landing Site of Tanjung Luar, Lombok Timur, West Nusa Tenggara (Figure 1). Biometric observations of the samples included of total body length, sex ratio and clasper length. Total samples of scalloped hammerhead was 118 fishes that consisted of 44 male and 74 female.

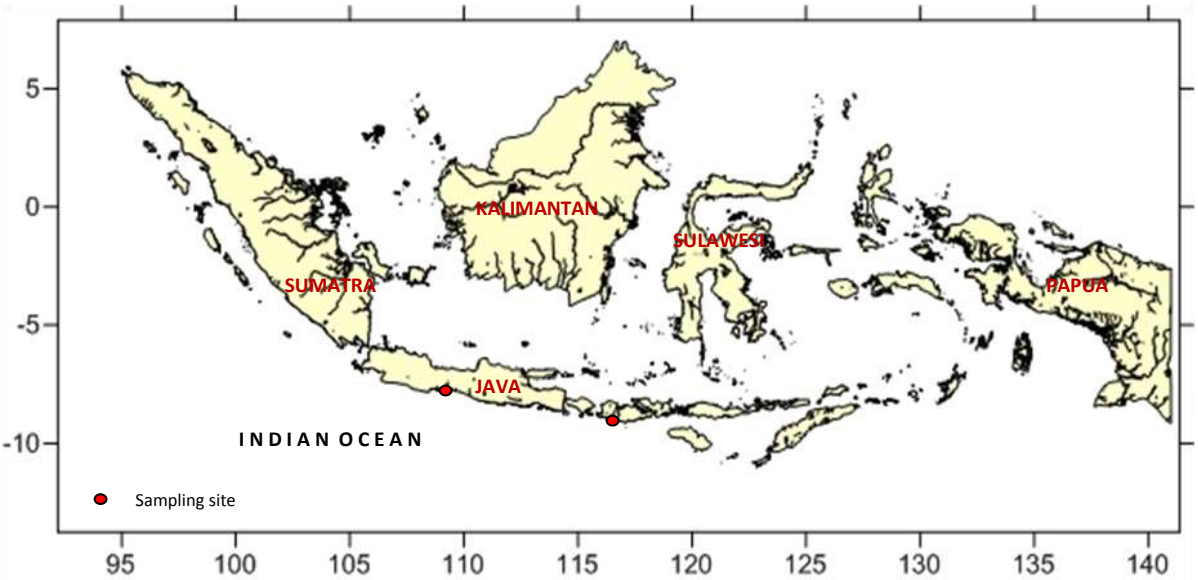

Figure 1. The fishing port of sampling location

Total length data was tabulated into the length-frequency table in the interval class of 10 cm using Microsoft excel program. Furthermore, length distribution presented on the graph with the differentiate the sex.

Sex ratio between males and females was analyzed using Chi-square test to determine the significant difference from the expected ratio 1 : 1 (Steel and Torie 1993). Maturity stage of males were classified based on the condition of claspers. The mature males were indicated by their calcified and enlarged claspers, while females were indicated as mature by the presence of embryos (White *et al.*, 2002).

RESULTS AND DISCUSSION

Sharks Production

Based on Capture Fisheries Statistic of Indonesia year of 2007 - 2011 the trend of national production of shark was fluctuated where there was decreased in the year of 2008 and then it was increased by the year 2009 to 2011 (Table 1). On the Table 1, it is also presented the production of sharks caught in Indian Ocean. In this case the production of Indian Ocean was part of sharks production of all Indonesia waters.

The average shared of sharks production of Indian Ocean was about 15,1% to the total sharks production of all Indonesia waters. The highest shared production from Indian Ocean come from makos (*Isurus sp.*; *Heptranchias sp.*) sharks species was about 43,6%, while the hammerhead (*Sphyrna sp.*; *Eusphyra sp.*) sharks only shared about 4,1%. It is indicated that hammerhead sharks had the lowest population in the Indian Ocean of Indonesia waters.

Table 1. Production of shark in Indonesia waters year of 2007 - 2011

Species of sharks	Production of all Indonesian waters (MT)					Production of Indian Ocean waters (MT)				
	2007	2008	2009	2010	2011	2007	2008	2009	2010	2011
Hammerhead	1423	2366	3112	3438	3394	66	10	389	10	102
Thresher	13767	9385	8210	12890	18240	1949	3225	1488	2151	783
Requiem	29687	26000	28378	26454	23934	5576	2391	3585	5084	6603
Makos	497	461	830	733	632	64	89	443	523	386
Dogfish	12066	5413	5302	2585	4014	14	790	47	48	697
Total sharks	**57462**	**43638**	**45995**	**46153**	**50214**	**7675**	**6516**	**6115**	**7827**	**8571**

Source : DGCF (2007 - 2011)

While, the shared production of thresher shraks (*Alopias sp.*), requiem sharks (*Charcarinus sp.*) and dogfish sharks (*Squalus sp.*; *Centrophorus sp.*) form Indian Ocean were about 17.52%, 17.48%, and 6.96%, respectively.

Size composition

Length frequency distribution of scalloped hammerhead shark showed that the total length of females distributed from 51 to 300 cm and males from 127 to 244 cm. The scalloped hammerhead females and males were dominated by the size of 145 cm and 155 cm, respectively (Figure 2). The range sizes of females were wider than males and the maximum total length of females was also higher. This could be meant that the growth rate of females was higher than males.

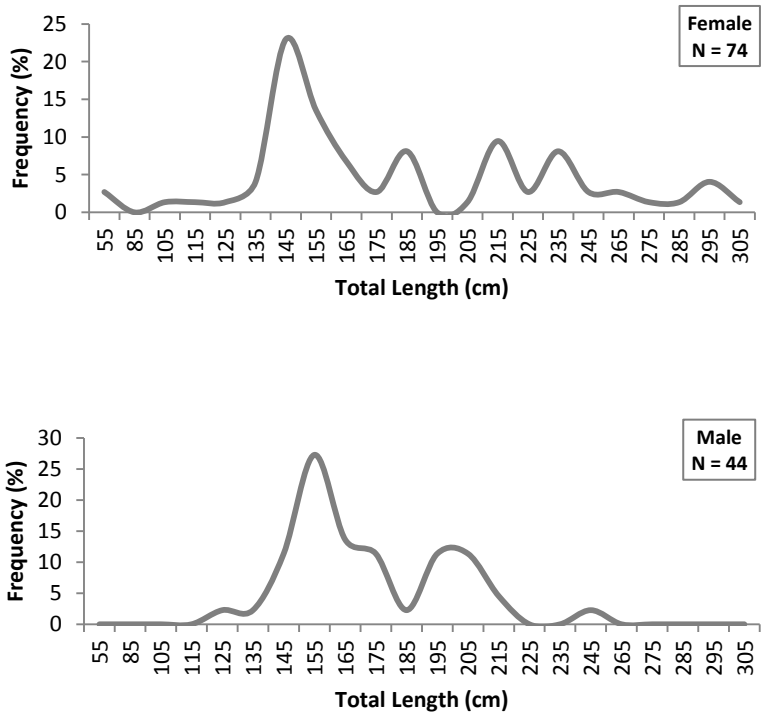

Figure 2. Length distribution of female and male scalloped hammerhead shark from Indian Ocean Southern of Java

In this study, we found that about 2.7% of the females were caught at the size of 51 cm and it was considered as the smallest species recorded. This size was categorized as juvenile (at size between 44 and 62 cm). According to White *et al*. (2006), total length of scalloped hammerhead sharks could be reaching the size of 370 - 420 cm. Mature males of scalloped hammerhead was in the range of 165 - 175 cm, while female was in the range of 220 - 230 cm. This result showed that more than a half (86,48% of females and 68,18% of males) of scalloped hammerhead were immature fishes.

This condition would be jeopardized for the sustainability of scalloped hammerhead shark resource especially and sharks in generally, because of the biological characteristics of these species. Sharks are long lived, have a long gestation periods (9 to 22 months), slow growth, late age at maturity (10 to 20 years for some species), low fecundity and low natural mortality (Coleman, 1996; Camhi *et al.*, 1998; Steven *et al.*, 2000; Bonfil, 2002; Cavanagh et al., 2003 *in* Fahmi and Sumadhiharga, 2007).

Sex ratio

Sex ratio is a number that indicates the ratio of males to females in a population and naturally the ratio of males and females was 1:1 (Bal and Rao, 1984). The overall ratio between males and females of the scalloped hammerhead shark, *S. lewini* during this study was 1: 1.68 and it showed a significant difference from the expected ratio 1:1 ($\chi^2 = 3.814$, $P < 0.05$). The unequal sex ratio indicated that the number of scalloped hammerhead shark caught in the Indian Ocean was dominated by females. It is could be also said that females were caught more frequent than males. There was an idea of segregation between females and males that occurred at different area, as mentioned by Heithaus (2001). Another possiblility was adult females may occur at shallower waters to give birth (Simpfendorfer, 1992).

Furthermore, according to Brykov *et al*. (2008) the sex ratio was related to the amount of fish produced in the next generation and as a population control measure. It was estimated that unequal of sex ratio will be increasing the susceptibility of scalloped hammerhead shark to be overexploited.

Length at maturity

The relationship between claspers length to total body length is usually used to determine the size at mature of male elasmobranch (Stevens & McLoughlin, 1991 *in* Carrier *et al*., 2004). They have two part of claspers in the right and left side as a reproductive function but only one clasper which delivered the sperm into the female's cloaca during

copulation process. Beside of getting longer, the clasper would be also getting bigger because of the process of calcification. Von Schmidt & Clark *in* Carrier *et al*. (2004) mentioned that the process of calcification and progression (hardness and stiffness) on clasper used as a standard for determining the level of sexual maturity in Elasmobranch.

In Indonesia waters, males of scalloped hammerhead sharks, *S. lewini* attained their maturity at 165 cm to 175 cm TL (White *et al.*, 2006). Figure 3 shows the relationship between the length of claspers and the total length of male scalloped hammerhead. In this study, the first maturity of male was estimated at size 162 cm TL. In northeastern Brazil, males of *S. lewini* reached maturity at size between 180 and 200 cm TL (Hazin *et al.*, 2001).

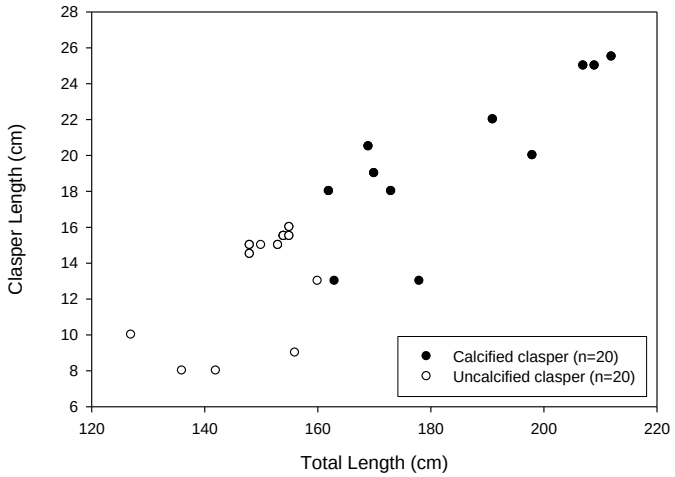

Figure 3. The relationship between total length and length of hammerhead sharks clasper

The size at maturity of males scalloped hammerhead shark in this study was presumably shorter than the size mentioned by Hazin *et al.*, (2001) and White *et al.*, (2006). This condition indicate that fishing pressure of this species were high.

According to White *et al.*, (2006), females of *S. lewini* attained their maturity at size 220 cm to 230 cm TL. During this study, pregnant females were recorded at size between 279 cm to 300 cm TL. The number of embryos in the uteri varied from 24 to 40 embryos and the size between 15 cm and 53 cm TL, depending on embryonal development stage. A scalloped hammerheads females at the size of 300 cm TL was recorded carrying 38 embryos at the size between 34 cm to 38 cm TL and the average weight of 220.1 grams. While, others mature *S. lewini* at the size of 279 cm TL was carrying 24 embryos at the size between 32 cm to 36 cm TL and the average weight of 200 grams. In the previously study in the western Indonesia, it was mentioned that females of scalloped hammerhead was mature at the size between 283 cm to 306 cm TL (Fahmi and Sumadhiharga 2007).

In this study, the size at maturity of females scalloped hammerhead shark from southern of Java was much larger than those mentioned by Compagno (1999) or recorded from other region such as northeastern Brazil but presumably same to the previously study in the western of Indonesia. The size at sexual maturity for females of *S. lewini* ranged from 213.5 to 255 cm TL in the northeastern Brazil, and the number of litters ranged from 2 to 20 embryos with the size ranged from 3 cm to 38 cm TL (Hazin *et al.*, 2001). Due to inadequate data of mature females during this study, the result for length at maturity of female *S. lewini* was not representative.

Conservation status

World Conservation Union (IUCN) classifies of scalloped hammerhead shark as "Endengered (EN) status" in the IUCN red list table since 2009 (IUCN 2013). This status is given to *Sphyrna lewini* because it is considered to be facing a very high risk of extinction in the wild. In addition, generally scalloped hammerhead shark more vulnerable to over exploitation than other sharks because of their characteristics, where this species have longer gestation periods than other sharks. These characterictics makes this species should be managed wisely. On the other hand, based on the results of the 16th CoP to CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) on March 2013, a group of kind hammerhead sharks (*Sphyrna sp.*) were agreed to be included in the Appendix 2 of CITES. Thus international trade of those species are limited and must be following the regulations of CITES.

In general, fisheries management which is not in function yet have the bad impact to the fisheries resources. Suman (2012), stated that one of the indicators that fisheries management not in function yet is the unavailability of the time series data base for active fishing vessels (as an indicator of "the real fishing effort") as well as inaccurate of the data and information collection. Therefore, data and information should be always gathered for fisheries management purpose so that we can control the exploitation of this species.

CONCLUSION

Young and females scalloped hammerhead shark were caught more frequent in the Indian Ocean Southern of Java. This condition remind that sharks resources should be managed wisely for their sustainability. Fisheries manager have to find out the better solution for shark fisheries.

ACKNOWLEDGEMENTS

This paper was a contribution of research activities developing new assessment and policy frameworks for Indonesia's marine fisheries, including the control and management of Illegal, Unregulated and Unreported (IUU) Fishing year of 2010 to 2011 at the Research Center for Fisheries Management and Conservation (RCFMC) and also the contribution of research activities of sharks in the Indian Ocean South of Java WPP 573 year of 2010 in the Research Institute for Marine Fisheries (RIMF), Muara Baru, Jakarta. Best acknowledegment to Dr. William White of the ACIAR-CSIRO, Australia for sharing knowledge and cooperation during the research take place.

REFERENCES

Bal, D. V & K.V. Rao. 1984. *Marine Fisheries*. Ata Mc Graw-Hill Publ. Co. Ltd., New Delhi. 470 p.

Carrier, J. C., J. A. Musick, & M. R. Herthaus. 2004. *Biology of Sharks and their relatives*. Texbook. CRC Press. Washington D. C. 596 p.

Compagno, L. J. V. 1999. Sharks. *In*: K E. Carpenter, and V. H. Niem (eds.). FAO Species Identification Guide for Fishery Purposes. The living marine resources of the Western Central Pacific. Volume 2. Cephalopods, crustaceans, holuthurians and sharks. FAO, Rome. pp. 1193-1366.

DGCF, 2007-2011. Capture Fisheries Statistics of Indonesia 2007-2011. Directorate General of Capture FisheriesMinistry of Marine Affairs and Fisheries. Jakarta.

Fahmi & Sumadhiharga, K. 2007. Size, sex and length at maturity of four common sharks caught from western Indonesia. *Mar. Res. Indonesia* Vol. 32, No. I : 7-19

Hazin, F, A. Fischer, and M. Broadhurst. 2001. Aspect of reproductive biology of the scalloped hammerhead shark, Sphyrna lewini, off northeastern Brazil. *Environmental Biology of Fishes*, 61:151-159.

Heithaus, M. R. 2001. The biology of tiger sharks, Galeocerdo cuvier, in Shark Bay, Western Australia: sex ratio, size distribution, diet, and seasonal changes in catch rates. *Environmental Biology of Fishes*, 61: 25-36

IUCN. 2013. The IUCN Red List of Category changes - Summary Statistics. Retrieved 9 June 2013, from http://www.iucnredlist.org/about/summary-statistics#Tables_7

Simpfendorfer, C. 1992. Biology of tiger sharks (*Galeocerdo cuvier*) caught by the Queensland shark meshing program off Townsville, Australia. *Aust. J. Mar. Freshwater Res.*, 43: 33-43.

Steel, R.D.G. & J.H. Torrie. 1993. *Prinsip dan Prosedur Statistika , Suatu Pendekatan Biometrik*. Terjemahan B. Sumantri. Jakarta: PT. Gramedia Pustaka Utama.

Suman, A. 2012. Strengthering sustainable management of shark resource. National Commission for Fish Stock Assessment. Seminar on Sustainable Management Policy of Shark and Review of Implementation Progress of NPOA Shark and Ray. IPB International Convention Center. 20-21 November 2012.

White, W. T., N. G Hall, and I. C. Potter. 2002. Size and age compositions and reproductive biology of the nervous shark Carcharhinus cautus in a large subtropical embayment, including an analysis of growth during pre- and postnatal life. *Marine Biology*, 141:1153-1164.

White, W. T., P. R. Last, J. D. Stevens, G. K. Yearsley, Fahmi, & Dharmadi. 2006. Economically important sharks and rays of Indonesia. National Library of Australia Cataloging-in-Publication entry. Australia. 329 p.