Identification of Vulnerable Species and Biological of Sharks from the Indian Ocean (SEASTAR2000)

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ABSTRACT
Many species of sharks contributing to the most important shark fisheries of the world inhabit the Indian Ocean, including Indonesia waters. Extensive data collecting from various fish landing sites in south- eastern Indonesia was conducted from April 2001 to March 2006 using market survey methods. The aim of this study was to identify the species of sharks from shark fisheries and observe their biological aspects. The results showed that there were 86 species of sharks identified, belonging to 21 families. Several species were categorized as vulnerable, such as: *Centrophorus squamosus* (Centrophoridae), *Isurus paucus, Isurus oxyrhinchus* (Lamnidae), *Charcharias taurus* (Odontaspididae), and *Carcharhinus longimanus* (Carcharhinidae). Sharks are usually caught by long lines and gillnets. The biological aspects including size range of each species, sex maturity stage, sex ratio, and fishery aspects were described as well.

Keywords: **biological aspects, vulnerable sharks, shark fisheries, Indian Ocean**

INTRODUCTION

Indonesia is one of the richest elasmobranchs faunas and the largest chondrichthyan fishery in the world. The World Conservation Union considered that 20% of the 547 species of sharks on the Red List are threatened with extinction (IUCN, 2006). There are 375 to 500 species of sharks in the world, composing of Carcharhiniformes (56%), Squaliformes (23%), Orectolobiformes (8%), and Lamniformes (4%) (FAO., 2000). Fahmi and Dharmadi (2005) reported that there were about 200 chondrichthyan species in Indonesian waters. The high diversity of the elasmobranch fauna in Indonesia has been well documented by Carpenter and Niem (1999); White *et al.*, (2006). Sharks are widely recognized as being vulnerable to over fishing due to their slow growth, late maturity and produce relatively few young (Lack and Sant, 2006).

Sharks are exploited mainly for their fins and meat, but also for their skin and lately for their cartilages. This material has gained popularity in the alternative health circuit in recent years as a treatment for variety of diseases, including cancer, arthritis and skin disorders. Those may lead to destructive fishery practices in some areas (Visser, 1997). They are used as a food item in many parts of the world, and shark-fin soup is particularly popular in Asian countries.

Shark populations are declining all over the world. The populations are declining mainly due to over-fishing due to the massive utilization. Elasmobranchs are caught in Indonesia by both target fisheries and as bycatch in other fisheries. Target fisheries, which are mainly artisanal, use a variety of fishing methods, such as shark surface longlines, shark bottom longlines, and bottom gillnets to target species. Tuna long lines, tuna gillnet, and trammel net result in by-catch (Keong *in* Camhi *et al.*, 2008). Data from the ongoing tuna monitoring programme showed that shark bycatch from the tuna fleets formed about 11 % of shark landings in Indonesia (Blaber *et al.*, 2009).

Although Indonesia has the largest shark fisheries and is considered to have one of the richest population of sharks in the world, there is a lack of information on the vulnerable species landed. This paper describes the size of species, sex maturity stage, sex ratio, and shark fisheries characteristic as well.

MATERIALS AND METHODS

The chondrichthyan catches at various landing sites in Indonesia were recorded on nine occasions between April 2001 and March 2006. Six landing sites were visited on the majority of sampling occasions, *i.e.* Palabuhanratu (West Java), Cilacap (Central Java), Kedonganan (Bali), Tanjung Luar (Lombok), Kupang (East Nusa Tenggara), and Merauke (West Papua) (Figure 1). Shark species were identified using the keys and–or illustrations

in Compagno *et al*. (1984), Last and Stevens (1994), Compagno (1998) and Gloerfert-Tarp and Kailola (1984). All measurements referred to their total lengths (TL) which were measured as a straight line from the tip of the snout to the tip of the extended upper caudal-fin lobe. In the case of males, the clasper length (Lc) from pelvic-fin insertion to apex of clasper (to the nearest 1 mm) and extent of calcification, i,e. non-calcified, partially-calcified or fully-calcified, were recorded if time allowed.

RESULTS

Size of species

The sizes by total length of some vulnerable sharks species caught in the Indian Ocean during our observation (2001—2006) are listed in Table 1. Their morphology is presented in Figure 2.

Male of *Isurus paucus* were caught in size between 149 and 228 cm, and from 203 to 298 cm for female. White *et al.,* (2006) reported that this species can attain at least 417 cm, males get mature at 205-228 cm, and females at about 245 cm (Last and Stevens, 2009), and they are born at 97-120 cm. Their habitat is oceanic, as an epipelagic species that is considered to be deep-dwelling. Sometimes it can be caught together with *Isurus oxyrinchus*. Size by total length of *Isurus oxyrinchus* of males is between 164-218 cm, and 150-248 cm for females. Last *et al.,* (2010) reported the size of this species to be at least 390 cm, male and female mature at about 185-195 cm and 250-280 cm respectively, they are born at about 60-70 cm. Reproductive biology is viviparous, with oophagy and possibly adelphophagy, giving birth to litters of 2-8 pups after an unknown gestation period. This species is caught irregularly by the tuna and shark longline fisheries (White *et al*, 2006). Male of *Carcharhinus longimanus* were caught in size from 66 to 245 cm TL and 69-261 cm TL for females. This species can be caught at a depth of 40-120 m (Chen, 1997), while White *et al.,* (2006) reported that this species can attain at least 300 cm, possibly to 350-395 cm, males mature at 190-200 cm and females mature at 180-200 cm, they are born at 60-65 cm. Its habitat is oceanic, pelagic from the surface to at least 152 m, usually well offshore and only close to land when the continental shelf is narrow. Its reproductive biology is viviparous, with a yolk-sac placenta, gives birth to litters of 1-15 pups after a gestation period of 12 months. Occasionally, this species was caught in shark and tuna longline and tuna gillnet fisheries. Male of *Centrophorus squamosus* were caught by size 52 – 100 cm for male and 106-125 cm for female. It was reported to be caught by size from 78-131 cm total length in the central Indian Ocean (Anderson and Hafid, 1997). Last and Stevens (2009) reported that in Australian waters, this species is born at 35-40 cm and attained at least 164 cm, while mature male is about 100 cm and female at 110-125cm, and it would not get mature until it reaches 20-40 years.

Sex maturity stage

Observation of the sex maturity level was only made for male sharks. Based on the results of measuring the clasper length, it can be grouped into three categories namely *non-calcified clasper*, *non or parcially calcified clasper*, and *fully calcified clasper.* In immature shark male, the claspers are small and flexible. Upon reaching maturity, the claspers calcify, harden, and form articulations with the pelvic fin base (Carrier *et al.,* 2004). In this study (Table 1) male of *Isurus paucus* and *Isurus oxyrhinchus* are known to mature at 258-276 and 175-210 cm respectively. *Carcharhinus longimanus* male is mature at 152-186 cm. There was no information on size at maturity for *Centrophorus squamosus* and *Carcharhinus taurus* due to the lack of sample records.

Sex ratio

One of the success factors of fish reproduction in maintaining the population is by determining sex comparison or the sex ratio. Sex ratio is very important for recruitment process of the species population, and the balance of the species population is affected by the comparison between the number of males and females.

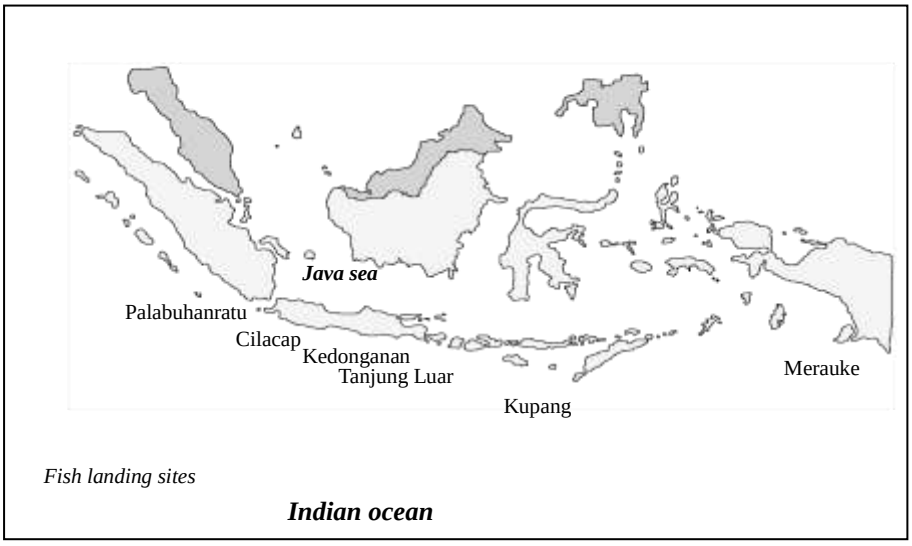

Figure 1. Map of the study area and observed fish landing sites.

According to this study, the sex ratios of *Isurus paucus*, *Isurus oxyrinchus* and *Carcharhinus longimanus*, were 1 : 1,63; 1 : 1,1 and 1:1,1 . There were no data available for *Carcharhinus taurus* and *Centrophorus squamosus.* In general the sex ratios for all vulnerable shark species caught in the Indian ocean were in imbalance.

Shark fisheries characteristics

Most of the shark fishing activities in Indonesia are artisanal. A large proportion of sharks captured in Indonesia waters was commonly as by-catch from tuna longlines and gillnet fisheries, fish nets, trammel nets and also as target from shark surface longlines and shark bottom longlines. Fishing activities were conducted in inshore and offshore. Shark fishing vessels operating in coastal waters (inshore) were commonly less than 10 gross tones (GT) using gillnet and bottom longline. The fleets operating offshore commonly used surface gillnet, and surface longline. In general, small sized sharks were caught in relatively shallow waters, while the sharks caught offshore were generally large size and had reached their maturity stage. The shark season was indicated by the number of fishing and the number of by-catch landings each month. These were also related to the weather condition. The rainy season and strong winds can cause the big waves at sea, and this situation prevents most fishermen from going fishing. This condition usually happens from December to March (wet season). In contrast, there are many fishing activities when there are no strong winds and waves on the sea, this generally happens from April to October (dry season) (Dharmadi *et al*., 2008).

DISCUSSION

Based on the size of vulnerable sharks caught in the Indian Ocean and compared to the size of the sharks in the same species caught in Australian waters, it can be mentioned that the vulnerable sharks caught in the Indian Ocean were at adult mature size. Sharks are particularly vulnerable to overfishing due to their tendency to take many years to become sexually mature and have relatively few offsprings. Despite the very high level of exploitation of sharks in Indonesia, it is somewhat surprising that, in a number of the abundant species, individuals close to their maximum sizes are still being observed in the catches. It should be noted, however, that there is very little published biological information on most of the vulnerable species of shark recorded in this study (Table 1), thus many of the previously documented maximum sizes are likely to be based on limited data from small sample sizes.

Table 1. Total length, size of sex maturity stage, sex ratio of vulnerable species of sharks caught in the Indian Ocean in a year 2001-2006

Year	Family/Species	Range of total length (cm)	Size of Sex maturity stage (mm)	Sex ratio (%)	Individual number
	LAMNIDAE				
2001-2006	*Isurus paucus*	M = 149-228 F = 203-298	NC = 78 NFC = 124 FC = 258	M = 38 F = 62	13
	Isurus oxyrhinchus	M =164-218 F =150-248	NC = - NFC =91-160 FC =175-210	M=47 F=53	34
	CARCHARHINIDAE				
2001-2006	*Carcharhinus longimanus*	M = 66-245 F = 69-261	NC = 48 NFC = 85 FC = 152	M = 47 F = 53	32
	Carcharhinus taurus	-	-	-	2
	CENTROPHORIDAE				
2002	*Centrophorus squamosus*	M = 52-100 F = 106-225	-	-	5

Remark : NC=*Non Calcification*; NFC=*Non Full Calcification*; FC=*Full Calcification*

Differences in size of vulnerable shark species caught in the Indian Ocean may be caused by differences in their biology and life history. Sex ratios of some vulnerable sharks that have been caught in the Indian Ocean are varied. This will influence the recruitment process, while a species of fish will be successful if the ratio of males and females was equal (1:1) (Sparre and venema, 1992). The recruitment process is also influenced by other factors such as availability of the parent, predators and habitat conditions in the environment. Sparre and Venema, (1992) mentioned that the recruitment process of a species is influenced by several factors such as fishing activity, fishing gear used and the size of fish caught.

The Indonesian artisanal fisheries are diverse and catch large numbers of chondricthyans throughout the year. Thus, any forms of future fisheries regulations in Indonesia may need to focus initially on individual fisheries rather than the condrichthyan fisheries as a whole. White (2003) mentioned that the greatest concern for the condrichthyan fisheries in Indonesia was the high level of unreported catches, and the lack of any real management plans. The critical factor in conservation and management of sharks is mortality incurred by fishing (Lack and Sant, 2006).

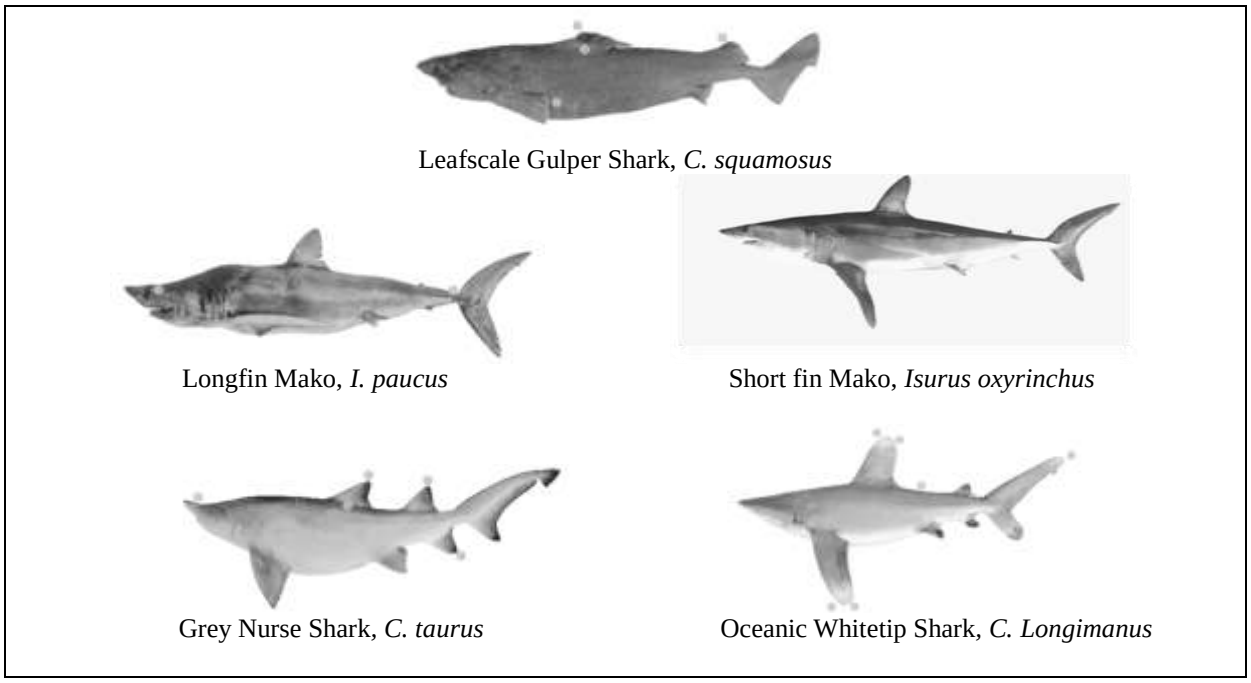

Figure 2. Several vulnerable sharks caught in the Indian ocean (White *et al*., 2006)

According to Badrudin (2010) fisheries management measures can be categorized into control of fishing and control of fishing effort. Related to this, the Directorate General of Capture Fisheries (DGCF), Ministry of Marine Affairs and Fisheries Republic of Indonesia has published a field guide of National Plan of Action (NPOA) shark and ray management and implemented it at the beginning of 2010. The recommendation aims to improve species-specific catch and landings data collection, monitoring and management of shark fisheries. Gilman *et al*. (2007) mentioned to prepare for a possible effective the data collecting, monitoring and precautionary shark management measures to ensure that shark fishing mortality levels are sustainable. The document of NPOA-Indonesia included the important areas relating to conservation and management of sharks and rays internationally. The scope includes the position of geography, biodiversity, distribution, endemic species, and the aspects of shark and ray fisheries which will be carried out at national and regional levels (DGCF, 2010).

CONCLUSION

All of the vulnerable sharks caught in the Indian Ocean were at adult size. However, the male and female sex ratios were in imbalance. Although shark exploitation in Indonesia is categorized as artisanal fishery, it needs serious attention because the fishing activities are carried out continuously, and can impact on the decreasing shark population. The characteristics of shark biology with long life, slow growing and low reproduction are such that they are vulnerable to extinction. Its biological characteristics have serious implications for

sustainability of shark fisheries. Therefore, necessary sustainable shark fisheries management should be taken in action according the NPOA.

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