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BIODIVERSITY AND LENGTH FREQUENCIES OF SHARKS CAUGHT IN THE INDIAN OCEAN

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ABSTRACT

Study on biodiversity and size structure of sharks in the Indian Ocean was conducted at several landing sites and fish markets, i.e. Pelabuhanratu (West Java), Cilacap (Central Java), Kedonganan (Bali) and Tanjung Luar (East Lombok). Field observation was done from April 2001 to March 2006. The results showed that there were 86 species of sharks belonging to 16 families in the Indian Ocean. The sharks were dominated by family of Carcharhinidae and Squalidae with 24 and 23 species, respectively. A high diversity of sharks was found at Kedonganan-Bali (49 species), at Tanjung Luar (47 species), at Cilacap (32 species) and at Pelabuhanratu (27 species). Size of sharks landed at those landing sites varied in length, the length of *Carcharhinus amblyrhynchos* was between 90 cm and 170 cm TL, *C. sorrah* (55-155 cm), *C. obscurus* (205-295 cm) and *P glauca* was caught at length between 205-300 cm.

Keywords: Sharks, Biodiversity, Length frequencies, Indian Ocean

INTRODUCTION

Sharks are classified in the order of Selachii, which together with the skates and rays of the order of Batoidei make up the sub class Elasmobranchii, and sharks are dominant fishes among the cartilaginous fishes (Demski and Wourms, 1993). The diversity of the cartilaginous fishes was significantly high in Indonesian waters (Gloerfelt-Tarp and Kailola, 1984; Last and Stevens, 1994; Carpenter and Niem, 1998). According to Goerfelt-Tarp and Kailola (1984), sharks consisted of 84 species which were caught by trawls in the southern Indonesian waters and the north-west of Australia. Whiles the diversity of sharks was recorded of about 375 to 500 species in the world, which were dominated by order Carcharhiniformes (ground sharks; 56%). Other major groups of Elasmobranchs are Squaliformes (dogfish sharks), Orectolobiformes (carpet sharks), and Lamniformes (mackerel sharks) that respectively comprise 23%, 8%, and 4% of the living sharks (Demski and Wourms, 1993; FAO, 2000).

Indonesia is known as having the highest diversity of elasmobranches (sharks and rays) in the world (Blaber, 2006), with their fishery production reported as 87,138 tones in 1993 and 100,000 tones in 1996 (Monintja and Poernomo, 2000; Widodo, 2000). In 2004, sharks and rays were landed about 108,694 tones (Directorate General of Capture Fisheries, 2006), and approximately 60,000 tones of sharks, which was significantly decreasing (Blaber, 2006). Various parts of shark body could be utilized such as their meats and fins for foods, skins for leather industries, and liver oil and cartilages for medicines. The most valuable part of the shark body is its fins, and they are usually exported to Asian countries (Anonymous, 2003). Whiles the salted and dried shark meat are traded either locally or exported especially to Bangladesh and Srilangka (Pers. comm.). Trade statistics revealed that, during 2000 and 2001, Hongkong imported 1,400 tones of shark fins, (both

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with and without cartilages) from Indonesia (Anonymous, 2003). Squalene oil is commonly produced from the shark liver especially from the family Squalidae and it is exported to almost Asian countries (Blaber, 2006).

Sharks are usually caught locally as target fisheries and also as by catch. Target fisheries use a variety of fishing methods, such as gill and tangle nets, long lines and harpoons (Dharmadi and Fahmi, 2003). Although Indonesia has the largest shark fishery and is considered to have one of the richest sharks in the world, but there is almost no information on biological data or size compositions of species landed. In a region where shark populations are amongst the most heavily exploited, taxonomic knowledge of Indonesia's sharks needs improving to provide an adequate baseline for data acquisition and resource management.

The size of sharks from Indian Ocean varied in lengths which were depending on both species and their habitat. Their length frequencies could be use for either their growth or age estimation (Sparre and Venema, 1992). Despite of their abundance, elasmobranchs are particularly vulnerable to over fishing due to their biological characteristics. Sharks and rays are slow maturing and long lived, but do not have high levels of fecundity (Wourms and Leo, 1993). This paper presents information on shark diversity and size composition of some sharks species caught from the Indian Ocean.

MATERIALS AND METHODS

Study on elasmobranch species was conducted from April 2001 to March 2006 at several landing sites along the coast of Indian Ocean, particularly from Pelabuhanratu (West Java), Cilacap (Central Java), Kedonganan (Bali), and Tanjung Luar (East Lombok), Those sites were visited regularly during the study. Twenty one trips were done in Kedonganan and Tanjung Luar, and 15 trips were done in Cilacap and Pelabuhanratu (Fig. 1). Each trip was conducted within 2 – 7 days.

Shark species was identified using descriptions in Compagno *et al.*(1984), Last and Stevens (1994), Compagno (1998; 1999) and Gloerfelt-Tarp & Kailola (1984). All measurements of sharks referred to their total length (TL), which was measured as a straight line from the tip of the snout to the tip of the extended upper caudal-fin lobe. Length frequency assessments were analyzed to only four carcharhinid species, which were *Carcharhinus amblyrhynchos*, *C. sorrah, C. obscurus* and *Prionace glauca.*

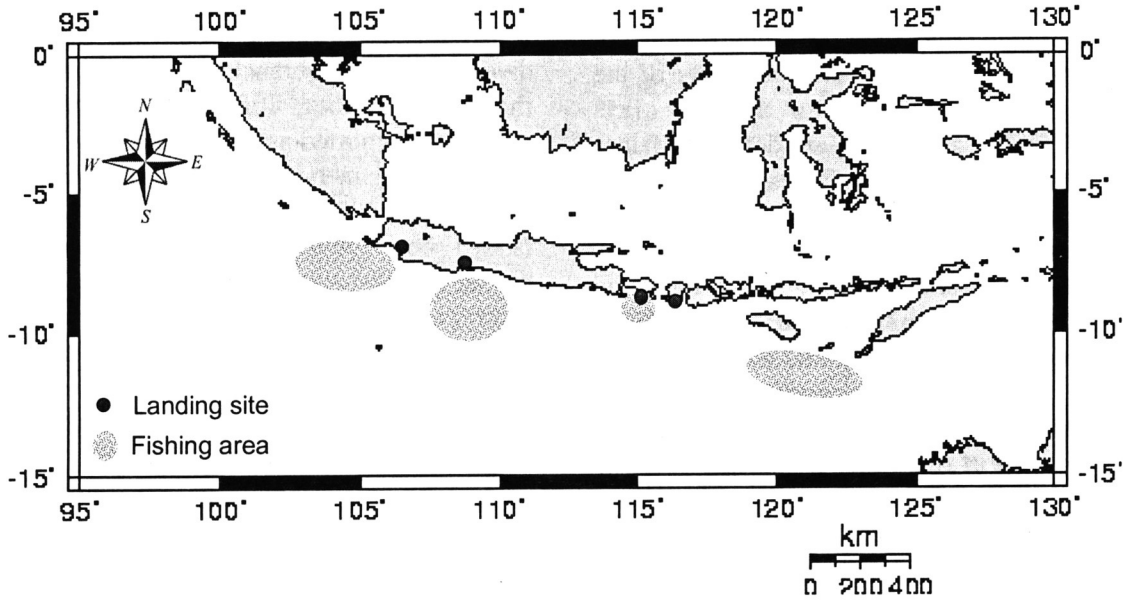

Figure 1. Map of the study area and observed landing sites Java, Bali and West Nusa Tenggara.

RESULTS

Biodiversity

From four landings, we identified 86 species of sharks belonging to 16 families. The dominant families were the Carcharhinidae (27%), and the Squalidae (26%).The highest diversity of sharks was found in Kedonganan (44 species), while from Tanjung Luar was found 45 species, Cilacap was 31 species, and Palabuhanratu was 27 species. All species found are listed in Table 1. In general, the most common shark species found in Indian Ocean was *Carcharhinus falciformis*, and the dominant families were Carcharhinidae and Squalidae (Table 1; Fig. 2).

Table 1. Diversity of Sharks in Indian Ocean from Pelabuhanratu, Cilacap, Kedonganan and Tanjung Luar landing sites.

Family and Species	Common Names	Palabuhanratu (West Java)	Cilacap (Central Java)	Kedonganan (Bali)	Tj. Luar (East Lombok)
Hexanchidae					
Heptranchias perlo	Sharpnose Sevengill Shark	+	+	+	
Hexanchus griseus	Bluntnose Sixgill Shark			+	+
Squalidae					
Centrophorus cf. *isodon*	Blackfin Gulper Shark			+	+
Centrophorus sp. 1	Gulper Shark			+	
Centrophorus cf *granulosa*	Gulper Shark			+	+
Centrophorus lusitanicus	Largefin Gulper Shark				+
Centrophorus cf *moluccensis*	Smallfin Gulper Shark			+	
Centrophorus cf *niakung*	Taiwan Gulper Shark	+	+	+	
Centrophorus cf *squamosus*	Leafscale Gulper Shark	+	+	+	
Centrophorus cf *uyato*	-			+	+
Cirrhigaleus cf *barbifer*	Mandarin Dogfish			+	+
Isistius brasiliensis	Cookiecutter Shark	+	+	+	+
Squalus cf *japonicus*	Japanese Spurdog		+	+	
Squalus sp. 1	Indonesian Greeneye Spurdog	+	+	+	+
Squalus sp. 2	Indonesian Greeneye Spurdog	+		+	+
Squalus sp. 3	Indonesian Shortnose Spurdog		+	+	
Squalus sp. C	Indonesian Highfin Spurdog		+	+	+
Centrophorus cf *atromarginatus*	Dwarf gulper shark	+			
Orectolobidae					
Orectolobus sp. 1	Spotted wobbegong			+	+
Orectolobus cf. *japonicus*	Japanese wobbegong	+			
Orectolobus cf. *ornatus*	Indo wobbegong	+			
Hemiscyllidae					
Chiloscyllium punctatum	Brownbanded Bambooshark			+	+
Chiloscyllium sp. cf. *punctatum*	Brownbanded Bambooshark				+
Stegostomatidae					
Stegostoma fasciatum	Zebra shark				+
Ginglymostomatidae					
Nebrius ferrugineus	Tawny nurse shark			+	+
Odontaspididae					
Carcharias taurus	Sand tiger shark			+	
Pseudocarchariidae					
Pseudocarcharias kamoharai	Crocodile Shark	+	+	+	+
Alopiidae					
Alopias pelagicus	Pelagic Thresher		+	+	+
Alopias superciliosus	Bigeye Thresher	+	+		

Family and Species	Common Names	Palabuhanratu (West Java)	Cilacap (Central Java)	Kedonganan (Bali)	Tj. Luar (East Lombok)
Lamnidae					
Isurus oxyrinchus	Shortfin Mako	+	+	+	+
Isurus paucus	Longfin Mako				+
Scyliorhinidae					
Atelomycterus marmoratus	Coral catsharks			+	+
Atelomycterus sp. cf. *marmoratus*	Coral catsharks			+	
Cephaloscyllium sp. E	-			+	+
Cephaloscyllium sp.	-		+		
Haleolurus boesamani	Speckled catshark		+	+	
Parmaturus cf *melanobranchius*		+			
Triakidae					
Hemitriakis cf *leucoperiptera*				+	+
Hemitriakis sp. 1	Indonesian houndshark			+	
Mustelus cf *griseus*	Spotless smoothhound	+	+	+	+
Mustelus sp. 1	Whitefin smoothhound			+	
Mustelus sp. 2	Blackfin smoothhound			+	+
Hemigaleidae					
Chaenogaleus macrostoma	Hooktooth shark		+		
Hemigaleus microstoma	Sicklefin weasel shark			+	+
Carcharhinidae					
Carcharhinus albimarginatus	Silvertip shark	+		+	+
Carcharhinus altimus	Bignose shark				+
Carcharhinus amblyrhynchos	Grey reef shark	+			+
Carcharhinus amboinensis	Pigeye shark			+	+
Carcharhinus brevipinna	Spinner shark	+	+	+	+
Carcharhinus dussumieri	Whitecheeks shark				
Carcharhinus falciformis	Silky shark	+	+	+	+
Carcharhinus leucas	Bull shark		+		
Carcharhinus limbatus	Common blacktip shark		+	+	+
Carcharhinus longimanus	Oceanic whitetip shark		+		+
Carcharhinus macloti	Hardnose shark	+	+		
Carcharhinus melanopterus	Blacktip reefs shark			+	+
Carcharhinus plumbeus	Sandbar shark		+		+
Carcharhinus obscurus	Dusky whaler		+	+	+
Carcharhinus sorrah	Spot-tail shark	+	+	+	+
Galeocerdo cuvier	Tiger shark		+		+
Loxodon macrorhinus	Sliteye shark	+			+
Prionace glauca	Blue shark		+		+
Rhizoprionodon acutus	Milk shark	+	+	+	+
Rhizoprionodon oligolinx	Grey sharpnose shark	+	+		+
Triaenodon obesus	Whitetip reef shark	+		+	+
Sphyrnidae					
Sphyrna lewini	Hammerhead shark	+	+	+	+
Sphyrna mokarran	Hammerhead shark				+
Sphyrna zygaena	Hammerhead shark	+	+		
Squatinidae					
Squatina sp	Angelshark	+			
Total families		**12**	**10**	**14**	**15**
Total species		**27**	**31**	**44**	**45**

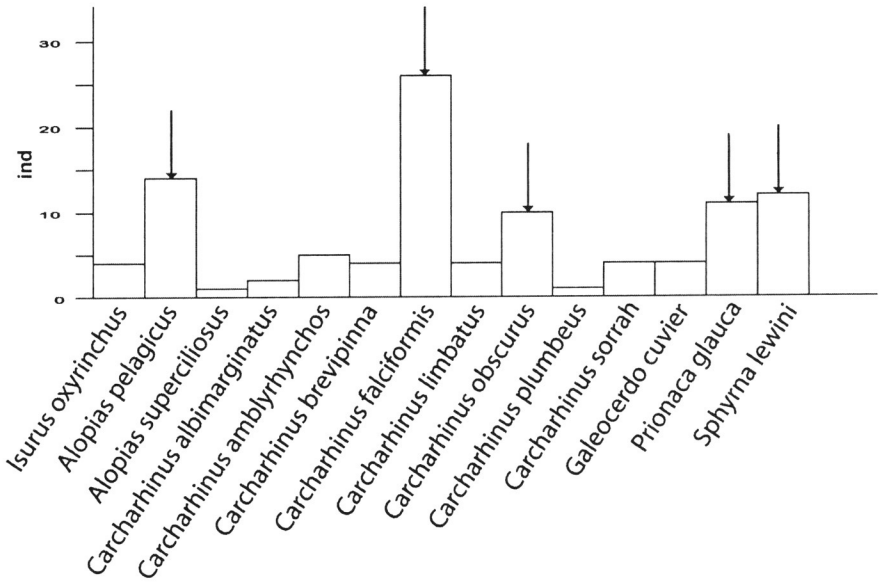

Figure 2. The most abundant shark species in Indian Ocean.

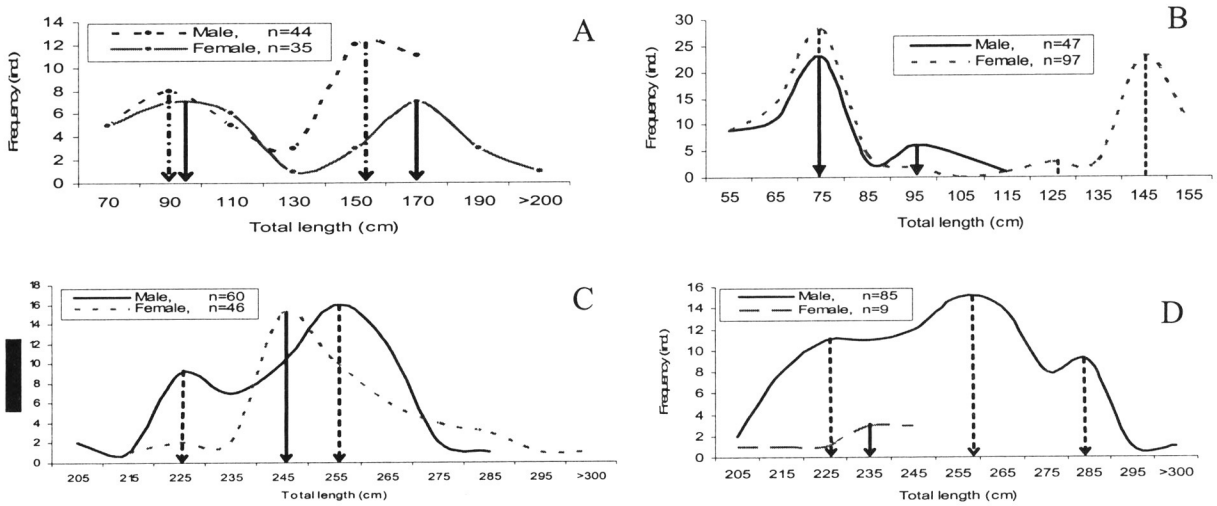

Figure 3. Length frequency distributions of (A) *C. amblyrhynchos,* (B) *C. sorrah,* (C) *C. obscurus,* and (D) *P. glauca.*

Length frequencies

Figure 3 showed that females of *C. ambyrhynchos* was abundant at size classes of 95 cm and 170 cm, while males suggested to have high abundant at size classes of 90 cm and 150 cm. Females *C. sorrah* had at least three abundant size classes with the peaks of length at 75 cm, 125 cm, and 145 cm. The males of this shark species had at least two abundant size classes with the peaks at 75 cm and 95 cm. Both females and males of *C. obscurus* had two abundant size classes with the peaks of length at 225 cm, 255 cm for males, while females were at 225 cm and 245 cm, respectively. Meanwhile, Males of *P. glauca* were abundant at least at three size classes, with the peaks of length at 225 cm, 260 cm, and 285 cm.

The size composition according to their maturity stages were separated into three group of maturity level. Percentages of mature, immature and postmature sizes of four carcharhinid species from our observation are listed in Table 2.

DISCUSSION

According to Compagno (1997), fish markets could be the best places to collect shark sample

Table 2. Percentage contribution of maturity stages (mature, immature and postmature) of four carcharhinid sharks from the Indian Ocean during the study.

Species	Percentage			
	Mature	Immature	Postmature	Sex
C. amblyrhinchos	2.3	51.4	40	Female
	34.1	40.9	25	Male
C. sorrah	1.03	58.8	40.2	Female
	10.6	89.4	-	Male
P. glauca	22.2	11.1	66.7	Female
	22.4	2.4	75.3	Male
C. obscurus	54.3	43.5	2.2	Female
	5	95	-	Male

from the coastal areas as well as from the ocean. Moreover, the data also could be used to assess their abundance. However, the biodiversity study of sharks taken from fish markets was significantly different than those which came from a direct sampling study in certain water (Pers. obs.). Regarding from all landing sites, sharks were caught by various fishing gears, such as bottom long-lines, surface long-lines, gillnets, trammel nets, bottom trawls, and drop lines, both as target fisheries and also as by catch. In general, fisheries that catch sharks as by catch were usually operated using bottom trawls, trammel nets, gillnets, long-lines, and drop lines. While the target shark fisheries usually used gillnets, trammel nets, long-lines, and harpoon as their fishing gears. Those fishing gears which utilized as target fisheries were particularly carried out in Tanjung Luar.

During our observation, we found as follows: At Cilacap, the most common shark species were *Alopias pelagicus* (Alopiidae) and *Carcharhinus faciformis* (Carcharhinidae). They were caught by surface gillnets and tuna long-lines. Whiles sharks that were caught by bottom long-lines were *Centrophorus niaukang, Squalus* sp. (Squalidae) and *Hydrolagus* sp. (Chimaeridae).

At Palabuhanratu, the most common shark species caught by surface long-lines were *Carcharhinus falciformis* and *Prionace glauca* (Carcharhinidae). While the common sharks caught by bottom long-lines was only *Centrophorus niaukang* (Centrophoridae). At Kedonganan, sharks were caught by using bottom gillnets and drop lines. The fishing-ground was about 5 – 10 miles with the depth of about 50 – 100 m. The fishing trips are usually only 1 – 2 days per trip. The common shark species from this landing site were *Squalus* sp. (Squalidae), *Carcharhinus brevipinna* (Carcharhinidae), and *Sphyrna lewini* (Sphyrnidae). At Tanjung Luar, the catches were dominated by *Carcharhinus amblyrhynchos, C. falciformis, C. sorrah, Galeocerdo cuvier, Triaenodon obesus* (Carcharhinidae), and *Sphyrna lewini* (Sphyrnidae).

The fishing gears used at Tanjung Luar were bottom long-lines and surface long-lines. The fishing grounds were located at surrounding of southern Sabu Island, southern Nusa Tenggara Timur, eastern Sumba Island, western Flores Island, eastern Ende Island, and surrounding of Cempi Island with the depth of about 150 m using surface long-lines. The surface longlines have the length of about 12000 – 13000 m, and the hook number of about 400 – 600 (no. 1); When using the bottom long lines, the fishers moved to the deeper fishing grounds such as at surrounding of Lombok, Sumbawa and Sumba Islands with the depth of about 100 – 200 m. The bottom longlines were set at length of about 1.000 – 2.000 m with the hook number of about 100 (no. 1).

According to White *et al.*, (2006) that the females of *C. amblyrhynchos* were mature at 125 – 135 cm, and the mature males at 130 – 149 cm. Females *C. sorrah* reach their maturity at 110 – 118 cm, and males at 103 – 115 cm. While *C. obscurus* were mature at 257 – 300 cm for the females and at 280 – 300 cm for the males. Both sexes of *P. glauca* were mature at 210 – 220 cm. Therefore, the four shark species above were caught at all maturity levels, some of them were caught at mature sizes and the rest at small and medium of immature sizes.

Figure 3 also shows that the females of *C. sorrah* were caught in equal number between the young and mature sizes. In coastal waters of

Cleveland, the north-east Australia, most of *C. sorrah* were caught in various sizes from the young sizes to the mature sizes, which were between 54 cm and more than 86 cm (Colin and Milward, 1993). In this study, we found that the size composition of *C. sorrah* from the Indian Ocean was larger than those of the previous investigation. In general, most of *C. amblyrhinchos* and *C.obscurus* were caught in the maturing stages, *C. sorrah* was in immature and maturing stages while most of *P. glauca* were caught in the mature stages. However, more accurate information of their mature sizes is still needed. There was not significant differentiation yet in the length frequency of female *P. glauca* between the lowest and highest class, because limited samples were collected. Whereas for males, the smallest length were found on the size between 200-210 cm and the most common large sizes were found at the size of about 250-260 cm (Fig. 3d). The study result on the highest length frequency of males for the same species was similar in sizes to the result from Northeast Brazil. However, the size at the first gonad maturity in the both males and females of *P. glauca* that were found there was at the 225cm and 228 cm (Lessa *et al.*, 2003). In the Northeast Atlantic, the female *P. glauca* were caught from 64-228 cm with the peak length frequency distribution at 155 cm TL. While the male sizes distributed from 95-219 cm with the peak at 146 cm (Handerson *et al.*, 2001). According to Hanan *et al.*, (1993) the size of the mature males of *P. glauca* were about 153-183 cm in standard length, and when we observed the development of claspers, the gonad maturity of males was at the size of about 183 cm in standard length or 218 cm in total length.

CONCLUSION

In 2001-2006 we recorded about 86 species of them belonging to 16 families indicating high diversity of sharks from the Indian Ocean. The dominant families were Carcharhinidae and Squalidae, and the most common species of sharks was *Carcharhinus falciformis*. Shark fishery in Tanjung Luar was apparently as a target fish, whereas in the other sites were as by catch. The sizes of sharks of the Carcharhinidae were varied from small until medium sizes and some of them were in mature stages, particularly for *P. glauca.*

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