BIODIVERSITY OF SHARKS AND RAYS IN SOUTH-EASTERN INDONESIA

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ABSTRACT

Indonesia has a very diverse shark and ray fauna and is the largest chondrichthyan fisheries in the world. Most of the sharks are caught by longlines and gillnets and rays are caught both as target, e.g. in the tangle net and demersal gillnet fisheries, and as bycatch in other fisheries such as in demersal and drift gillnet, trammel net and long line fisheries. The sharks and rays caught from the Indian Ocean, adjacent to Indonesia, were mostly landed at artisanal fisheries in south-eastern Indonesia, such as Pelabuhan Ratu (West Java), Cilacap (Central Java), Kedonganan (Bali), Tanjung Luar (East Lombok), and Kupang (West Timor), and Merauke (West Papua). Surveys were conducted at these fish landing sites between April 2001 and March 2006, with a total of 80 species of sharks belonging to 21 families recorded. The dominant shark family was the Carcharhinidae with 27 species. A high diversity of sharks was recorded at Kedonganan (49 species), at Tanjung Luar (47 species), at Cilacap (32 species), and at Pelabuhan Ratu (27 species). A total of 55 species of rays belonging to one of 12 families were recorded from the same landing sites. The most speciose and commonly recorded family of rays was the Dasyatidae, which was represented by 28 species, and contributed 65.2% to the total number of chondrichthyan individuals recorded. The most abundant dasyatids recorded were the smaller ray species *Neotrygon kuhlii, Dasyatis zugei,* and *Himantura walga,* and the larger species *Himantura gerrardi* and *Himantura fai* which collectively comprised 57.8% of the total number of all chondrichthyans landed.

KEYWORDS: ***shark, ray, biodiversity, south-eastern Indonesia***

INTRODUCTION

Indonesia is known as having the highest diversity of elasmobranches (sharks and rays) in the world (Blaber, 2006), with their fishery production reported as 100,037 tones in 2005 (Directorate General of Capture Fisheries, 2007) and then increased to be 110,528 tones in 2006 (Directorate General of Capture Fisheries, 2008). Most elasmobranches are caught opportunistically through-out Indonesian waters, mainly in coastal artisanal fisheries and bycatch of commercial shrimp trawlers (Keong *in* Camhi *et al.,* 2008). The reported elasmobranch landings in Indonesia consist of 66% sharks and 34% rays, of which, members of the Dasyatidae are, by far, the most dominant species (Carpenter & Niem, 1999; Stevens *et al.,* 2000). In 2006, a study conducted by fisheries scientist, Shelley Clarke, indicated that up to 73 million sharks are now being killed annually to supply the fin trade. This was three times higher than the official catch statistics reported by the FAO, because it included new data taken from illegal shark fin traders who unreported their catches (www.elasmodiver.com/Shark books).

The diversity of sharks was recorded of about 375-500 species in the world, which was dominated by the order of Carcharhiniformes (ground sharks; 56%). There are three other major groups, Squaliformes (dogfish sharks), Orectolobiformes (carpet sharks), and Lamniformes (mackerel sharks) that respectively comprise 23, 8, and 4% of the living sharks (Demski & Wourms, 1993; FAO, 2000). More than 400 species of chondrichthyes consist of sharks, rays, and chimaera (600 species) in the world (Camhi *et al.,* 1998); Compagno (1984; 2002). While Fahmi & Dharmadi (2005) estimated that Indonesian waters contain more than 200 chondrichthyan species.

The high diversity of the elasmobranch fauna in Indonesia has been well documented by Gloerfelt-Tarp & Kailola (1984), Last & Stevens (1994), Carpenter & Niem (1999). Elasmobranchs are caught in Indonesia by both as target fisheries and as bycatch in other fisheries. Target fisheries, which are mainly artisanal, use a variety of fishing methods, such as gillnets, trammel nets, purse seines, longlines, and droplines. The fisheries that land substantial catches of elasmobranchs as a bycatch include the prawn and fish fishery exploited by commercial trawlers and pelagic tuna fisheries. Although Indonesia has the largest chondricthyan fishery and is considered to have one of the richest chondrichthyan fauna in the world, there are almost no published biodiversity of sharks and rays in Indonesia. In a region where shark and ray population are amongst the most heavily

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exploited, taxonomic knowledge of Indonesia's chondricthyan fauna needs to improve in order to provide an adequate baseline for data acquisition and resource management (White *et al.*, 2006).

This paper describes on species identification and species composition of sharks and rays and their fishery at fish landing sites in south-eastern Indonesia.

MATERIALS AND METHODS

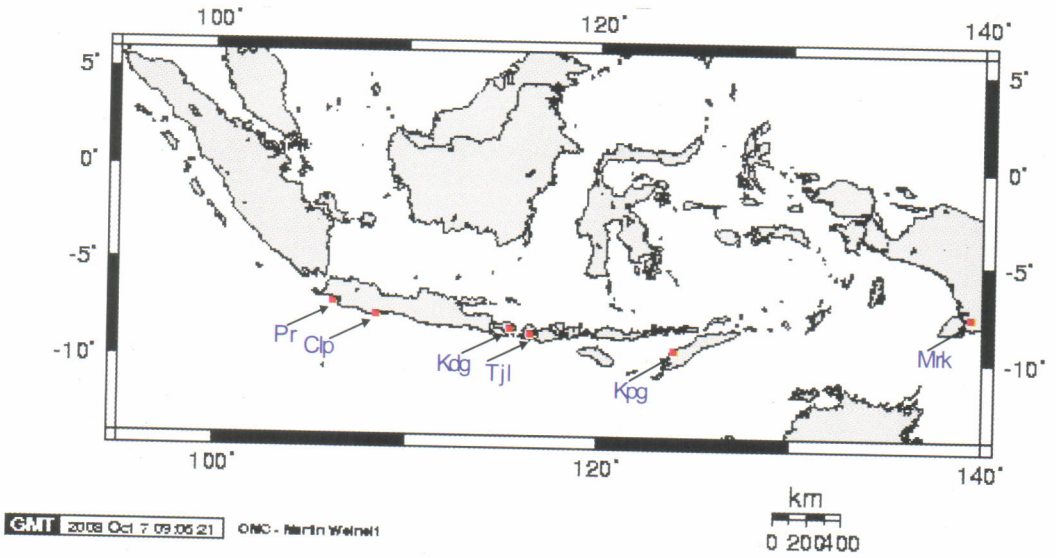
A study on elasmobranch species was conducted from April 2001-March 2006 at several landing sites and fish a long the coast of Indian Ocean, particularly from Pelabuhan Ratu (West Java), Cilacap (Central Java), Kedonganan (Bali), Tanjung Luar (East Lombok), Kupang (West Timor), and Merauke (West Papua). Those sites were visited regularly during the study. Twenty one trips were done at Kedonganan and Tanjung Luar, and fifteen trips were done at Cilacap and Pelabuhan Ratu, while one trip was done in Kupang and Merauke. Each trip was conducted within 2-7 days. Shark and ray species was identified using descriptions in Compagno *et al.* (1984); Last & Stevens (1994); Campagno (1998; 1999); Gloerfelt-Tarp & Kailola (1984). The location and a description of the landing sites surveyed in south-eastern Indonesia are given in Figure 1.

RESULTS

Diversity of Sharks and Rays

All species of sharks and rays found during this study are listed in Appendix 1. A total of 19,634 chondrichthyan fishes, representing 135 species and 29 families, were recorded collectively at the landing sites in south-eastern Indonesia between April 2001 and March 2006. This total specimen comprised of 80 species of shark representing 21 families and 55 species of ray representing 12 families. A high diversity of sharks was found at Kedonganan-Bali (49 species), at Tanjung Luar (47 species), at Cilacap (32 species), at Pelabuhan Ratu (27 species), and low diversity of sharks was found at Kupang and Merauke *i.e.* 5 and 4 species, respectively. While diversity of rays was found at each landing sites i.e. Kedonganan (32 species), Tanjung Luar (14 species), Cilacap (13 species), Pelabuhan Ratu (9 species), Merauke (5 species), and Kupang (2 species) (Figure 2).

The dominant sharks family was the Carcharhinidae with 27 species and they were recorded from this fishery in south-eastern Indonesia. However, the most common shark species found from this family were *Carcharhinus falciformis* and *Carcharhinus brevipinna,* which together comprised 27.1% of the total number of sharks caught (Appendix 1). Whereas the most specious and commonly recorded family of rays was Dasyatidae, represented by 23 species, and contributed 87.3% to the total number of ray individuals recorded. The most abundant Dasyatids recorded were the smaller ray species i.e. *Neotrygon kuhlii, Dasyatis zugei,* and *Himantura walga,* and the larger species was *Himantura gerrardi* which collectively comprised 84.2% of the total number of all rays landed. Most of sharks were caught by longlines where some species of sharks i.e. *Alopias pelagicus, Carcharhinus amblyrhynchos, Carcharhinus*



Remarks: Fish landing sites of Pr: Pelabuhan Ratu, Clp: Cilacap, Kdg: Kedonganan, Tjl: Tanjung Luar, Kpg: Kupang, Mrk: Merauke

Figure 1. Map of the study area and observed landing sites in south-eastern Indonesia.

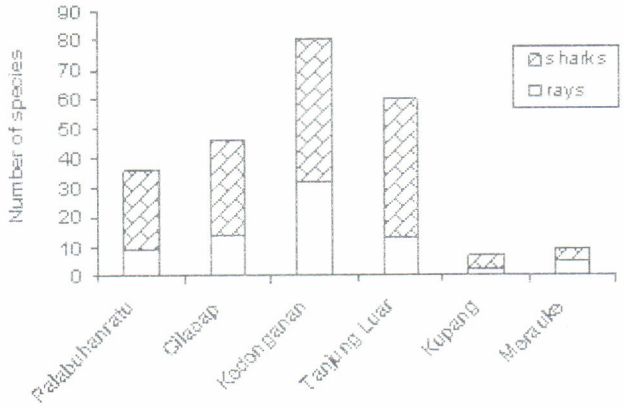


Figure 2. Numbers of species of sharks and rays recorded at each landing site.

falciformis, *Prionace glauca*, and *Sphyrna lewini* contributed 62% to the pelagic fisheries. Another abundant species from the tuna gillnet fisheries i.e. *C. sorrah, Rhizoprionodon oligolinx, and Scoliodon laticulatus* which together comprised contributed 55% to the pelagic fisheries, and only one species was caught i.e. *Prionace glauca* from the tuna longline fisheries and contributed 27% (Figure 3a). While the most abundant species of *Squalus hemippinis* contributed 42% to the demersal longline fisheries (Figure 3b).

The extents to which sharks and rays move within and between different habitats vary greatly. For example, the blue shark *Prionace glauca* is capable of trans-oceanic migrations in excess of 16,000 km, whereas some species of horn sharks have been observed foraging in the same area of reef each day and returning to shelter in the same cave every night (Tricas *et al.*, 1997). Some species, such as the grey reef shark, *Carcharhinus amblyrhynchos,* from small to large aggregations over reefs (Last & Stevens, 1994; Tricas *et al.*, 1997). Most Carcharhinidae i.e. silky shark (*Carcharhinus falciformis*) and spinner shark (*Carcharhinus brevipinna)* are highly migratory species and they are solitary and often over schools of tuna. Those species inhabit the continental and insular shelves and slopes, deepwater reefs, and open seas. They are also occasionally sighted in inshore waters (*Marinebio.org/species.asp.*). Most species of rays recorded were living in coastal and continental shelf and the some species which were found in the oceanic mainly the family of Mobulidae.

Based on morfometric methode, we estimated that probably at least there were 27 new species had been found in the south-eastern Indonesia during this study. However ten species have been published, such as some of them are *Hemitriakish indroyonoi* (White *et al.* 2009), *Mustelus widodoi* (White & Last, 2006), *Rhinobatos jimbaranensis* and *Rhinobatos penggali* (Last *et al.*, 2006) and 17 species are currently known. From all species of sharks and rays had been identified during this study we estimated that at least there were 16 species of them possibly endemic species in Indonesia waters, for instance species of *Hemitriakish indroyonoi, Himantura walga,* and *Dasyatis parvonigra* were found in south of Java Sea, *Rhinobatos jimbaranensis, Rhinobatos penggali, Atelomycterus baliensis,* and *Mustelus widodoi* were found in continental shelve close to the Bali and Lombok Island, and others endemic species had been found in continental shelve near Merauke-West Papua are *Dasyatis* sp.1 and *Himantura hotlei.*

Species Composition of Sharks and Rays

Species compositions of sharks were shown in Appendix 1. From the number of 6,107 individuals of sharks recorded, *Carcharhinus falciformis* and *Carcharhinus brevipinna* from the family of Carcharhinidae and *Squalus* spp. of the family of Squalidae were dominated, with the percentages of 14.9, 12.2, and 22.1% from the total individuals recorded, respectively. Whiles from 13,527 individuals of rays recorded, the family of Dasyatidae which was represented by *Neotrygon kuhlii, D. zugei, Himantura gerrardi, H. walga,* was dominated with percentages of 42, 17.9, 13.2, and 9.8% from the total individuals recorded, respectively.

The greatest number of species of sharks and rays recorded were at Kedonganan and Tanjung Luar, *i.e.* 81 and 60, respectively, and the least were at Kupang and Merauke, i.e. 7 and 9, respectively. The family of Carcharhinidae and Dasyatidae in this study made the greatest contribution to the total estimated biomass of chondrichthyans, *i.e.* 36.6 and 60.2%,

percentage contributed of the total number of shark individual recorded. Whereas, in Japanese waters, *Carcharhinus falciformis* is the most common target species of the shark fishery and also caught as bycatch by the swordfish and tuna fisheries. (Marinebio.org/species.asp.). Furthermore, Oshitani *et al.* (2003) mentioned that, the catch of silky shark (*Carcharhinus falciformis*) was the most common shark taken by purse seine fisheries in eastern Pacific Ocean and it contributed for 25% of all sharks caught.

Family of Dasyatidae was found in a large number at the continental shelve in both tropic and sub tropic in the world, where its members make a very important contributions to both the artisanal and commercial fisheries (Compagno, 1984; Carpenter & Niem, 1999). This family is represented by more than 60 living species that belongs to five genera, i.e. *Dasyatis, Himantura, Pastinachus, Taeniura,* and *Urogymnus,* with the majority residing in the first two of these genera (Last & Stevens, 1994). The small sizes of some commercial rays were dominated in the catches of rays in Asian countries (Carpenter & Niem, 1999), for example *Dasyatis kuhlii.* This species, which is very common in inshore waters in depths of up to about 90 m, occurs predominantly over sandy substrates (Last & Stevens, 1994). The dwarf whip ray *Himantura walga,* which is the smallest of the Dasyatid species, with a maximum disc width of only 180 mm, has a limited distribution in the Indo-West Pacific from Thailand to south-eastern Indonesia (Carpenter & Niem, 1999). The habitat of *Himantura walga* is poorly defined, but this species is the most common large coastal and in inshore waters.

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. Sharks are also caught locally by both target fisheries and as by catch. In general, fisheries that land substantial catches of sharks as bycatch are from bottom trawl, trammel net, gillnet, long-line, and drop line fisheries while the target shark fisheries usually use gillnets, and long-lines, which was particularly carried out in Tanjung Luar in this study. Oceanic pelagic sharks are usually caught longlines but sometimes they are also taken as bycatch by tuna fishers. The main species taken in the tuna longline fisheries is *Prionace glauca* (27%), while in the tuna gillnets, *Rhizoprionodon oligolinx* and *Scoliodon laticulatus* are dominant which collectively comprised 45%. On the other hand, *Carcharhinus falciformis* is the most common shark species taken by shark longlines (16%). While the main species taken by demersal longline is *Squalus hemippinis* (42%).

CONCLUSION

Family of Carcharhinidae was biggest percentage contribution in the shark's composition (47.3%) which dominated by *Carcharhinus falciformis* (14.9%) and *Carcharhinus brevipinna* (12.2%). While family of Dasyatidae was biggest percentage contribution in the rays composition i.e. 85.3% which was dominated by *Neotrygon kuhlii* (42%), *Dasyatis zugei* (17.9%), *Himantura gerrardi* (14.5%), and *Himantura walga* (9.8%). The findings of new species in the Indian Ocean indicated that the chondrichthyan diversity in Indonesia has not fully discovered yet. Besides, some species of shark and ray were endemic species in the south Java Sea and in continental shelve close to the Bali, Lombok Island, and Merauke during this study.

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Appendix 1. Biodiversity, habitat, and species composition of sharks and rays

Family and species	Common name	DS	Oc.	CCS	Percentage
SHARKS					
Carcharhinidae					
Carcharhinus albimarginatus	Silvertip shark			*	1.2
Carcharhinus altimus	Bignose shark			*	0.3
Carcharhinus amblyrhynchos	Grey reef shark			*	2.4
Carcharhinus amblyrhynchoides	Graceful shark			*	0.4
Carcharhinus amboinensis	Pigeye shark			*	0.2
Carcharhinus brevipinna	Spinner shark			*	12.2
Carcharhinus dussumieri	White cheeks shark			*	0.2
Carcharhinus falciformis	Silky shark		*		14.9
Carcharhinus leucas	Bull shark			*	0.3
Carcharhinus limbatus	Common black tip shark			*	2.4
Carcharhinus longimanus	Oceanic white tip shark		*		0.5
Carcharhinus macloti	Hard nose shark			*	0.3
Carcharhinus melanopterus	Black tip reefs shark			*	0.2
Carcharhinus plumbeus	Sandbar shark			*	0.2
Carcharhinus obscurus	Dusky whaler			*	1.3
Carcharhinus sorrah	Spot-tail shark			*	2.5
Carcharhinus sealei	Black spot shark			*	0.1
Galeocerdo cuvier	Tiger shark			*	0.5
Loxodon macrorhinus	Slit eye shark			*	0.3
Prionace glauca	Blue shark		*		3.5
Rhizoprionodon acutus	Milk shark			*	2.1
Rhizoprionodon oligolinx	Grey sharp nose shark			*	0.3
Rhizoprionodon taylori	Australian sharp nose shark			*	0.2
Triaenodon obesus	White tip reef shark			*	0.4
Scoliodon laticaudus	Spade nose shark			*	0.2
Negatron acutidens	Sickle fin lemon shark			*	0.1
Lamiopsis temmincki	Broad fin shark			*	0.1
Sphyrnidae					
Sphyrna lewini	Scalloped hammerhead		*	*	6.8
Sphyrna mokarran	Great hammerhead		*	*	0.3
Sphyrna zygaena	Smooth hammerhead		*	*	0.2
Eusphyra blochii	Wing head shark		*	*	0.1
Squatinidae					
Squatina legnota	Indonesian Angel shark			*	0.8
Scyliorhinidae					
Cephaloscyllium pictum	Speckled swellshark			*	0.2
Halaelurus maculosus	Indonesian spotted catshark			*	0.4
Atelomycterus marmoratus	Coral catshark			*	0.1
Atelomycterus baliensis	Bali catshark			*	0.3
Hexanchidae					
Heptranchias perlo	Sharp nose Seven gill Shark		*		0.5
Hexanchus griseus	Blunt nose Six gill Shark		*		0.7
Hexanchus nakamurai	Big eye Six gill Shark		*		0.6
Centrophoridae					
Centrophorus isodon	Black fin Gulper Shark		*		0.4
Centrophorus cf. lusitanicus	Large fin Gulper Shark		*		0.1
Centrophorus moluccensis	Small fin Gulper Shark		*		1.1
Centrophorus niakung	Taiwan Gulper Shark		*		0.8
Centrophorus squamosus	Leaf scale Gulper Shark		*		0.5
Centrophorus atromarginatus	Dwarf gulper shark		*		0.2
Deania cf. calcea	Indonesian bird beak dogfish	*			0.1

Appendix 1. Continue

Family and species	Common name	DS	Oc.	CCS	Percentage
Dalatidae					
Isistius brasiliensis	Cookie cutter Shark		*		0.1
Dalatias licha	Kite fin Shark		*		0.15
Squalidae					
Squalus montalbani	Philippine Spurdog	*			6.0
Squalus edemudsi	Edmunds Spurdog	*			4.6
Squalus hemippinis	Indonesian Shortnose Spurdog	*			7.5
Squalus nasutus	Western Longnose Spurdog	*			4.0
Cirrhigaleus barbifer	Mandarin Dogfish	*			0.3
Orectolobidae					
Orectolobus cf. *ornatus*	Indo wobbegong			*	0.9
Hemiscyllidae					
Chiloscyllium punctatum	Brownbanded Bambooshark			*	0.8
Chiloscyllium plagiosum	Whitespotted Bambooshark			*	0.75
Chiloscyllium indicum	Slender Bambooshark			*	0.9
Stegostomatidae					
Stegostoma fasciatum	Zebra shark			*	0.6
Ginglymostomatidae					
Nebrius ferrugineus	Tawny nurse shark			*	0.7
Odontaspididae					
Carcharias taurus	Grey nurse shark			*	0.5
Odontaspis ferox	Sandtiger shark		*		0.4
Pseudocarchariidae					
Pseudocarcharias kamoharai	Crocodile Shark		*		0.95
Alopiidae					
Alopias pelagicus	Pelagic Thresher		*		7.0
Alopias superciliosus	Bigeye Thresher		*		0.9
Lamnidae					
Isurus oxyrhinchus	Shortfin Mako		*		0.8
Isurus paucus	Longfin Mako		*		0.1
Somniosidae					
Zameus squamulosus	Velvet dogfish		*		0.1
Pseudotriakidae					
Pseudotrakis microdon	False catshark		*		0.1
Scyliorhinidae					
Atelomycterus marmoratus	Coral catsharks			*	0.2
Atelomycterus baliensis	Bali catsharks			*	0.1
Cephaloscyllium pictum	Painted Swellshark			*	0.3
Haleolurus maculosus	Indonesian speckled catshark			*	0.1
Triakidae					
Hemitriakis sp.1	Indonesian houndshark			*	3.11
Iago garricki	Longnose houndshark			*	0.2
Mustelus cf manazo	Sparse-spotted smoothhound			*	0.3
Mustelus widodoi	Whitefin smoothhound			*	0.1
Hemigaleidae					
Chaenogaleus macrostoma	Hooktooth shark			*	0.2
Hemigaleus microstoma	Sicklefin weasel shark			*	0.1
Hemipristis elongata	Fossil shark			*	0.4
Paragaleus tengi	Traight-tooth weasel shark			*	0.3

Appendix 1. Continue

Family and species	Common name	DS	Oc.	CCS	Percentage
RAYS					
Dasyatidae					
Neotrygon kuhlii	Bluespoted stingray			*	42
Dasyatis cf. akajei	Yellowmargin stingray			*	0.2
Dasyatis sp.1 (grey, thorns)	Merauke tingray			*	0.5
Dasyatis microps	Smalleye stingray			*	0.3
Dasyatis zugei	Sharpnose stingray			*	17.9
Dasyatis parvonigra	Balinese stingray			*	0.1
Dasyatis neotrygon	Javanese maskray			*	0.5
Dasyatis cf. Ushiei	Indonesian cow stingray			*	0.4
Neotrygon annotata	Javanese maskray			*	0.35
Himantura leoparda	Leopard whipray			*	0.2
Himantura jenkinsii	Jenkins' whipray			*	0.25
Himantura walga	Dwarf whipray			*	9.8
Himantura fava	Honeycomb whipray			*	0.3
Himantura fai	Pink whipray			*	0.5
Himantura gerrardi	Whitespotted whipray			*	14.5
Himantura granulata	Feathertail stingray			*	0.03
Himantura toshi	Blackspotted whipray			*	0.02
Himantura uarnak	Reticulate whipray			*	0.07
Himantura uarnacoides	Blacker's whipray			*	1.1
Himantura astra	Black spotted whipray			*	0.01
Himantura hotlei	Hortle's whipray			*	0.02
Himantura pastinacoides	Round whipray			*	0.01
Pastinachus sephen	Cowtail stingray			*	0.04
Pastinachus solicorostris	Roughnose stingray			*	0.09
Pteropplatytrygon violacea	Pelagic stingray			*	0.02
Taeniura lymma	Bluespotted fantailray			*	0.04
Taeniura meyeni	Blotched fantailray			*	0.05
Urogymnus asperrimus	Percupine ray			*	0.03
Gymnuridae					
Gymnura poecilura	Longtail butterfly ray			*	0.7
Gymnura zonura	Zonetail butterfly ray			*	1.3
Gymnura japonica	Japanese butterfly ray			*	0.5
Myliobatidae					
Myliobatis tobijei	Kite ray		*	*	0.4
Aetobatus narinari	Whitespotted eagle ray		*	*	0.5
Aetobatos flagellum	Longheaded eagle ray			*	0.35
Aetomylaeus vespertilio	Ornate eagle ray			*	0.1
Aetomylaeus nichofii	Banded eagle ray			*	0.3
Aetomylaeus maculatus	Mottled eagle ray			*	0.2
Rhinopteridae					
Rhinoptera javanica	Javanese cownose ray			*	0.1
Rhinoptera sp.1	Short-tail cownose ray			*	0.1
Rhinidae					
Rhina ancylostoma	Bowmouth guitarfish			*	0.1
Narcidae					
Narcine sp.D	Indonesian numbfish			*	0.2

Appendix 1. Continue

Family and species	Common name	DS	Oc.	CCS	Percentage
Mobulidae					
Mobula japanica	Japanese devilray		*	*	0.8
Mobula tarapacana	Sicklefin devilray			*	0.9
Mobula kuhlii	Lesser devilray			*	0.5
Mobula thurstoni	Bentfin devilray			*	0.4
Manta birostris	Manta ray			*	0.7
Rhinobatidae					
Rhinobatos jimbaranensis	Jimbaran shovelnose ray			*	0.9
Rhinobatos typus	Giant shovelnose ray			*	0.75
Rhinobatos penggali	Indonesian shovelnose ray			*	0.6
Rhinobatos thouin	Clubnose guitarfish			*	0.5
Rhynchobatidae					
Rhynchobatus australiae	Whitespotted guitarfish			*	0.4
Rajidae					
Dipturus sp.1	Weng's skate		*		0.4
Okamejei cf. boesemani	Cute skate		*		0.3
Okamejei cf. powelli	Whitebloctched skate		*		0.1
Plesiobatidae					
Plesiobatis daviesi	Giant stingaree		*		0.35

Notes: DS = Deep Sea; Oc. = Oceanic; CCS = Coastal Continental Shelf. Total number of shark = 6,107 ind.; ray=13,527 ind.