Deriving More Information on Sharks and Rays of Southeast Asia for Sustainable Utilization and Management

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Sharks, rays, skates, and chimaeras are collectively known as cartilaginous fishes under the class Chondrichthyes. Cartilaginous fishes occupy a variety of habitats. In the Southeast Asian region, they are found in all oceans, from freshwater ecosystems to the deep abyss. At least 196 species of sharks, 160 species of rays, 30 species of skates, and seven chimaeras are found in the region. Comparative to other marine fishes, sharks are characterized by relatively slow growth, late sexual maturity, and a small number of young per brood. These biological factors make many shark species vulnerable to overfishing. Moreover, many shark species have been overexploited because their fins are highly valued for shark fin soup.

Sharks and rays are not targeted for most fisheries in the region, however, uncontrollable fishing activities with no proper actions taken to manage this resource could result in overexploitation. As part of the conservation and management, sharks, and rays species were proposed and included under the Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) starting from its 12th Conference of the Parties (CoP) in 2002. The growing number of listed species has increased the pressure on the international trade of sharks and rays. Non-detrimental findings (NDFs) by species to collect scientific data which includes landings, biological, socioeconomic data, and trade data is crucial to be conducted by the countries for the export purpose of species listed in Appendix II of CITES. Since 2015, MFRDMD has been actively conducting and implementing several research and activities at national and regional levels to enhance the sustainable utilization and management of sharks and rays in Malaysia and in the Southeast Asian region.

Landing data collection

In the Southeast Asian region, cartilaginous fish had received little specialized attention due to its low-level production as bycatches, especially by trawl nets. Compared with bony fishes, the landing of cartilaginous fish by countries in the region is generally less than two percent, except for Indonesia which is more than five percent. Meanwhile, some countries did not include sharks and rays landing in their national statistics.

In order to obtain better information on shark catch and landing, landing data collection program was therefore undertaken by the Southeast Asian Fisheries Development Center (SEAFDEC) through its Marine Fishery Resources Development and Management Department (MFRDMD) in collaboration with the Training Department (TD) in six Member Countries from 2015 to 2019. The landing data were collected from Cambodia (2018–2019), Indonesia (2015–2016), Malaysia (2015–2016), Myanmar (2018–2019), Thailand (2015–2016), and Viet Nam (2015–2016). In general, almost all species were utilized for human consumption. This activity was funded by the EU-CITES (2015–2016) and the Japanese Trust Fund VI (2018–2019).

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A total of 60 species of sharks, 78 species of rays, and eight species of skates were recorded. It was found that the catch composition of sharks, rays, and skates was less than 2 % of the total marine landings and the price range was USD 0.22–8.99/kg, USD 1.00–7.34/kg, and USD 0.20–2.00/kg, respectively.

In Malaysia, landing data collection was conducted at two major landing sites in Sabah, namely: Kota Kinabalu and Tawau in collaboration with the Department of Fisheries Malaysia (DoFM). The landing data of sharks and rays include species length, weight, sex, and appropriate information of the vessel that landed the catches. Individual specimens of sharks and rays were measured if the total number was less than 50 from each vessel. However, only 5–10 % were measured individually if the total number was more than 50. The results showed that Shark and ray landings contributed to about 0.4 % and 0.9 % of the total marine catch, respectively; and the main gear was trawl net. The most abundant shark species was *Chiloscyllium punctatum*, followed by *C. plagiosum,* and *Atelomycterus marmoratus*. As for rays, the most abundant ray species was *Neotrygon orientalis*, followed by *Maculabatis gerrardi*, and *Telatrygon zugei*. The recorded data by species is important to observe the abundance of sharks and rays in the fishery area while the data is vital in the preparation for NDFs study in the future.

Practical session during the Workshop on Landing Data Collection on Sharks and Rays held in 2020

Data collection by the designated enumerator in Kota Kinabalu, Sabah

Publications on data collection on sharks and rays in Malaysia

Marketing and trade survey

The marketing and trade survey on sharks and rays was conducted in collaboration with the Institute of Agricultural and Food Policy Studies, Universiti Putra Malaysia (IKDPM, UPM). The surveys were conducted in Sabah (2015), Perak and Pahang (2016), and Sarawak (2018). It was found that there were no finning activities onboard and all sharks and rays were brought back as a whole to jetties and fully utilized. In general, the marketing channels were highly localized and price ranges varied depending on size, species, and occasion.

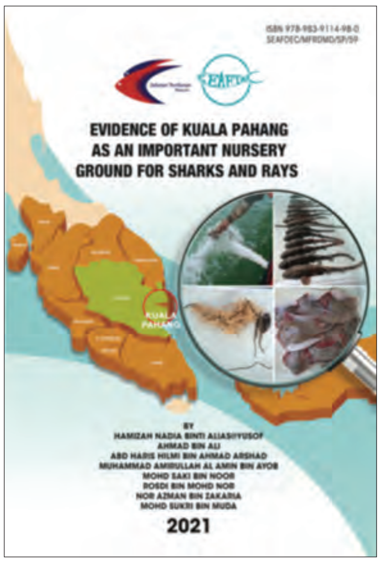
Meanwhile, in Indonesia, the Center for Fisheries Research, Ministry of Marine Affairs and Fisheries in collaboration with MFRDMD conducted two surveys in Java and Sumatera (2018) and in Kalimantan (2019). There was a high diversity of products produced from sharks and rays such as meat, skin, cartilage, teeth, intestine, and stomach. In addition, the demand for fins is still available with the biggest markets for fin-based trade in Asian and Southeast Asian countries. Live sharks and rays were also targeted by foreign markets for export through international airports.

Publications on the marketing and trade of sharks and rays in Malaysia and Indonesia

Nursery ground study of sharks and rays

A pilot study on the nursery ground of sharks and rays was conducted by MFRDMD in Kuala Pahang, Pahang, Malaysia. The State of Pahang has the highest landing of sharks and rays in Peninsular Malaysia. Fishers in Zone A (0–5 nm from shore) of East Coast Peninsular Malaysia are given a special permit to operate monsoon season trawl net (PTMT) below 2 nm from shore during northeast monsoon (November–March). The inspection that was carried out on trash-fish creel of fishers operated PTMT in Pahang found that many juvenile sharks and rays were caught together with other fishes and sold at a low price of around USD 0.1–0.2/kg. Concerning this finding, a study to identify the nursery ground of sharks and rays was conducted from November 2018 until March 2021 in Kuala Pahang waters and was supported by the DoFM with support from the JTF. All specimens caught during trawl activity were released back to the sea after recording length, weight, and sex data. A total of 1,139 individuals of sharks (three species) and 1,456 individuals of rays (13 species) were recorded with 98.8 % of sharks and 75.5 % of rays still at birth/juvenile stage. In addition, a collaborative study between MFRDMD and Universiti Malaysia Terengganu to determine the food

Sharks and rays at juvenile stage sorted out from low-value fishes caught by fishers operating monsoon season trawl net in Kuala Pahang, Malaysia



sources network using stable isotope analysis of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) proved that juvenile sharks and rays highly relied on the terrestrial linked carbon resources available in the study area. This study is also conducted in Nenasi waters in the southern part of coastal waters of Pahang starting in November 2021 and is expected to complete in March 2024.

Diversity of freshwater stingrays

MFRDMD collected samples of freshwater stingrays from the main river in the State of Pahang since 2004 and the species was confirmed to be *Fluvitrygon signifier* (**Figure 1**). From 2016 onward, more samples were collected from the States of Perak, Kelantan, and Johor. The discovery of *F. kittipongi* (**Figure 1**) in Perak in 2016 was considered to be a new record of species in Malaysia as it was previously found only in Thailand and Indonesia (Last *et al*., 2016). Later on, this species was also found in the main rivers and tributaries in Kelantan and Pahang. In addition, samples from rural areas in Johor were confirmed as *Urogymnus polylepis*. Although only three species could be confirmed up to the present, it is believed that many other species also inhabit rivers in Peninsular Malaysia, especially in the rural areas. Sample collection has therefore been actively undertaken especially in remote areas considering that it is crucial to update information on the biodiversity of freshwater stingrays to improve the sustainable management of these resources.

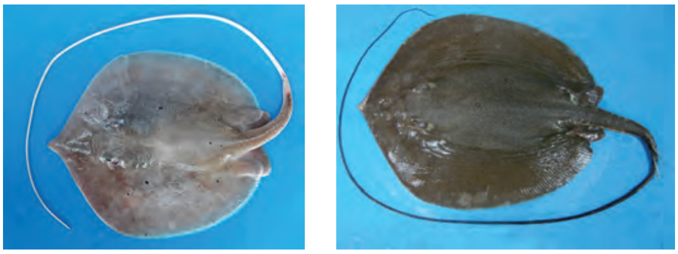


Figure 1. *Fluvitrygon signifier(left)* and *F. kittipongi (right)*

Species identification through DNA analysis

Accurate identification of shark species is one of the most challenging tasks, especially for look-alike species. While morphology is often the fastest and cheapest approach to identifying the species, other species identification methods are also necessary such as for those that are identical or when only some parts of the specimen are available. DNA barcoding is a taxonomic tool that uses a short-standardized piece of DNA sequence to identify an organism belonging to a specific taxonomic group (Hebert *et al*., 2003). The DNA marker commonly used for species identification in barcoding fishes is a 650-base fragment of the mitochondrial DNA called Cytochrome C Oxidase subunit I (COI) is proposed as a global standard because the variation in COI within species is lower relative to that among species. The nucleotide sequence for the selected marker is obtained and compared to a library of reference sequences which is stored and managed in online global databases (*e.g.* http://www.boldsystems.org). Ward *et al*. (2008) recommend this approach for marine ecologists working on chondrichthyans in the absence of expert taxonomists. The efficiency of this method in identifying and confiscating illegal species (Griffiths *et al*., 2013).

DNA barcoding is also possible when only part of an organism is available (John *et al*. 2016). In such cases, the method is useful in animal forensics (Holmes *et al*., 2009). Many researchers argued that elasmobranchs exhibit cryptic morphological overlapping characters, species complexity besides ontogenetic color patterns or variation which are shared among the closely related taxa that make accurate identification challenging (Cerutti-Pereyra *et al*., 2012; Sandoval-Castillo & Rocha-Olivares, 2011; Toffoli *et al*., 2008). It also leads to taxonomic misidentification in the field sampling and thereby affecting conservation-related research and fishery management. Therefore, DNA-based species identification was proposed and well-established on many cryptic taxonomic forms such as lepidopteron, fishes, spiders, polychaetes, and many other organisms (Blagoev *et al*., 2016; Burns *et al*., 2007; Hebert *et al*., 2003; Hebert & Gregory, 2005; Steinke, Prosser, & Hebert, 2016; Ward, *et al*., 2009).

Since 2013, DNA samples were collected from selected sites throughout the Southeast Asian region (**Figure 2**). A total of 145 shark, 250 ray, and 20 skate specimens were successfully sequenced for DNA barcoding comprising 39 species of sharks, 42 species rays, and five skates (**Table 1**). Almost all samples showed high similarity percentage (> 99 %) with corresponding species data available in database. The samples with similarity below 98 % with unconfirmed species identity by their morphology were eliminated. The number of samples per species is shown in **Table 2** and the phylogenetic relationship among species of sharks and rays are shown in **Figure 3**. Samples collected from Sungai Perak

Figure 2. Study sites in Southeast Asia for the DNA sampling for sharks, rays, and skates

Table 1. Number of samples for DNA barcoding of sharks, rays, and skates from selected sites in Southeast Asia

Country	Landing site	Sharks	Rays	Skates
Cambodia	Sihanoukville	-	6	-
Malaysia	Bagan Panchor	20	20	-
	Hutan Melintang	1	-	-
	Sungai Perak	-	2	-
	Dungun	2	11	-
	Kuantan	54	65	-
	Nenasi	-	2	-
	Tanjung Gemuk	-	1	-
	Temerloh	-	8	-
	Mukah	16	32	-
	Kota Kinabalu	9	18	-
	Sandakan	9	27	-
	Tawau	-	2	-
	Beluran	-	2	-
Myanmar	Yangon	4	-	-
Thailand	Andaman Sea	4	7	2
	Phuket	-	4	7
Viet Nam	Vung Tau	26	43	11
	Total	**145**	**250**	**20**

Specimen collection in Kuantan Port, Pahang, Malaysia

Primers optimization for genetic study of sharks and rays

and Temerloh were freshwater ray, *Fluvitrygon kittipongi* and *F. signifer*. Using DNA barcoding, all samples identified at first as *Neotrygon kuhlii* were confirmed as *N. varidens* and *N. caeruleopunctate* according to DNA sequence by Last *et al*. (2016). DNA barcoding showed excellent progress to support and verify the findings, usually using morphometric and meristic data. MFRDMD had submitted the DNA barcodes for 34 species of sharks and 43 species of rays to the Barcode of Life Data System (BOLDSYSTEM) with six new records which can be accessed globally.

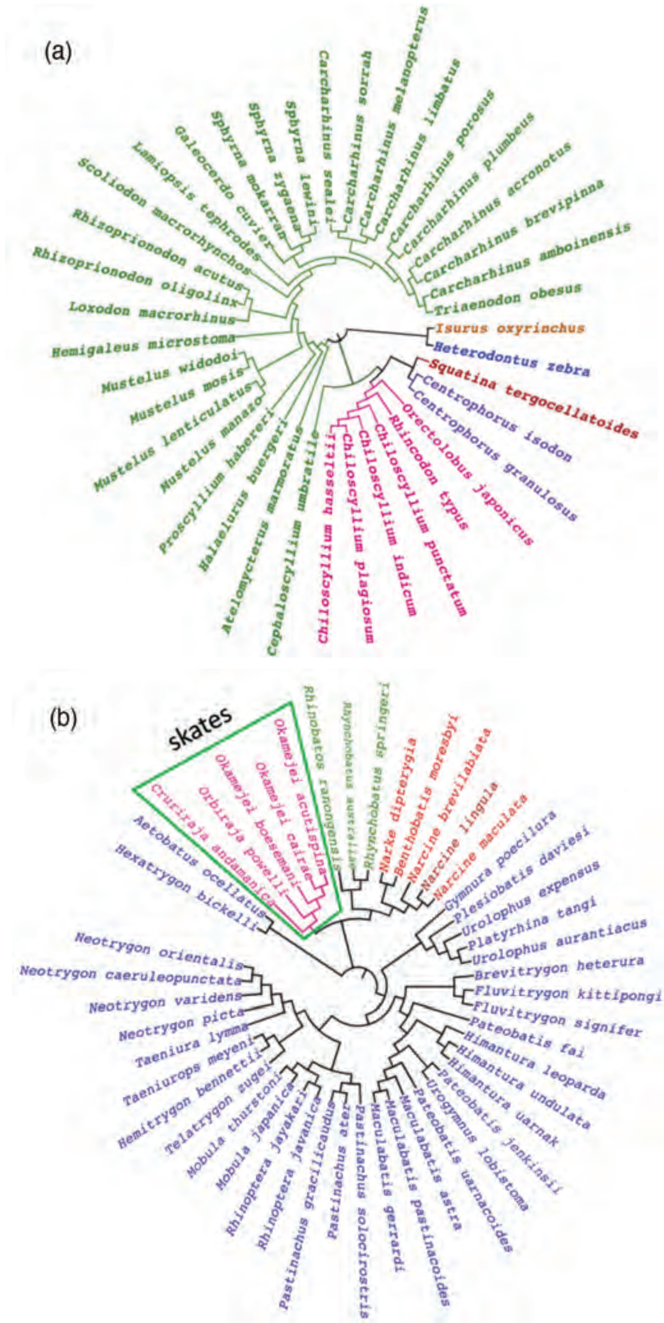


Figure 3. Phylogenetic relationship among sharks species **(a)** and among rays and skates species **(b)**
*(**Note:** color coding of text is also applied in **Table 2**)*

Table 2. DNA-barcoded species of sharks, rays, and skates

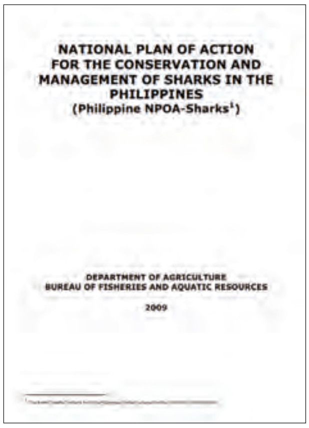
Sharks	n	Rays	n	Skates	n
Carcharhiniformes	**101**	**Myliobatiformes**	**198**	**Rajiformes**	20
Atelomycterus marmoratus	8	*Aetobatus ocellatus*	7	*Cruriraja andamanica*	2
Carcharhinus acronotus	1	*Brevitrygon heterura*	14	*Okamejei acutispina*	1
Carcharhinus amboinensis	1	*Fluvitrygon kittipongi*	2	*Okamejei boesemani*	3
Carcharhinus brevipinna	7	*Fluvitrygon signifer*	8	*Okamejei cairae*	7
Carcharhinus limbatus	5	*Gymnura poecilura*	20	*Orbiraja powelli*	7
Carcharhinus melanopterus	1	*Hemitrygon bennettii*	6	**Total**	**20**
Carcharhinus plumbeus	4	*Hexatrygon bickelli*	1		
Carcharhinus porosus	3	*Himantura leoparda*	13		
Carcharhinus sealei	7	*Himantura uarnak*	2		
Carcharhinus sorrah	5	*Himantura undulata*	1		
Cephaloscyllium umbratile	2	*Maculabatis astra*	1		
Galeocerdo cuvier	2	*Maculabatis gerrardi*	14		
Halaelurus buergeri	3	*Maculabatis pastinacoides*	7		
Hemigaleus microstoma	3	*Mobula japanica*	2		
Lamiopsis tephrodes	3	*Mobula thurstoni*	8		
Loxodon macrorhinus	2	*Neotrygon caeruleopunctata*	**2**		
Mustelus lenticulatus	2	*Neotrygon orientalis*	**4**		
Mustelus manazo	7	*Neotrygon picta*	**2**		
Mustelus mosis	1	*Neotrygon varidens*	**14**		
Mustelus widodoi	1	*Pastinachus ater*	**10**		
Proscyllium habereri	3	*Pastinachus gracilicaudus*	**7**		
Rhizoprionodon acutus	13	*Pastinachus solocirostris*	**5**		
Rhizoprionodon oligolinx	1	*Pateobatis fai*	**5**		
Scoliodon macrorhynchos	2	*Pateobatis jenkinsii*	**8**		
Sphyrna lewini	8	*Pateobatis uarnacoides*	**7**		
Sphyrna mokarran	3	*Plesiobatis daviesi*	**1**		
Sphyrna zygaena	1	*Rhinoptera javanica*	**6**		
Triaenodon obesus	2	*Rhinoptera jayakari*	**1**		
Heterodontiformes	1	*Taeniura lymma*	**6**		
Heterodontus zebra	1	*Taeniurops meyeni*	**2**		
Squaliformes	4	*Telatrygon zugei*	**5**		
Centrophorus granulosus	3	*Urogymnus lobistoma*	**2**		
Centrophorus isodon	1	*Urolophus aurantiacus*	**2**		
Lamniformes	**1**	*Urolophus expensus*	**3**		
Isurus oxyrinchus	1	**Rhinopritiformes**	16		
Orectolobiformes	**37**	*Rhinobatos ranongensis*	**1**		
Orectolobus japonicus	1	*Rhynchobatus australiae*	**13**		
Rhincodon typus	2	*Rhynchobatus springeri*	**2**		
Chiloscyllium hasseltii	13	**Terpediniformes**	***36***		
Chiloscyllium indicum	8	*Benthobatis moresbyi*	**4**		
Chiloscyllium plagiosum	5	*Narcine brevilabiata*	**5**		
Chiloscyllium punctatum	8	*Narcine lingula*	**12**		
Squatiniformes	**1**	*Narcine maculata*	**9**		
Squatina tergocellatoides	1	*Narke dipterygia*	**6**		
Total	**145**	**Total**	**250**		

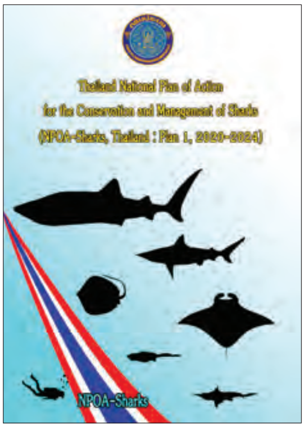
Shark conservation and management measures

In 1999, the Food and Agriculture Organization of the United Nations (FAO) adopted the International Plan of Action for Conservation and Management of Sharks (IPOA-Sharks) which is a voluntary instrument that applies to all States where fishers engage in shark fisheries. The IPOA-Sharks sets out a set of activities which States are expected to carry out, including an assessment of whether a problem exists with respect to sharks, adopting a National Plan of Action for the conservation and management of sharks (NPOA-Sharks), as well as procedures for national reviews and reporting requirements (FAO, 1999).

Malaysia was one of the first Southeast Asian countries to develop the National Plan of Action for Sharks (NPOA-Sharks). The first NPOA-Sharks was adopted in 2006 with the main objective to ensure the conservation and management of sharks and their long-term sustainable use. MFRDMD actively participated in preparation of NPOA-Sharks Plan 1 in 2006 and Plan 2 in 2014. The NPOA-Sharks Plan 3 is will be published in 2023. MFRDMD also actively participated in a collaborative activity with DoFM in updating Fisheries Regulations (Control of Endangered Species of Fish) 1999. In 2019, there were additional four species of shark and two species of ray as protected species under Malaysian Fisheries Act including *Sphyrna mokarran*, *S. zygaena*, *Eusphyra blochii*, *Carcharhinus longimanus*, *Manta alfredi*, and *M. birostris*.

The Philippines and Thailand also adopted their own NPOA-Sharks. Even though Philippines is not a major shark fishing nation, the country committed to develop its NPOA-Sharks and adopted it in 2009 as a member country of the FAO and as agreed upon during the 2nd ASEAN-SEAFDEC Regional Technical Consultation on Sharks Fisheries held in 2004. Moreover, Thailand established its plan of action during 2020–2024. The plan outlined the key actions necessary to improve the management and conservation of shark resources in Thai waters. For Viet Nam, the NPOA-Sharks is being developed for implementation during 2017–2025.



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Human resource development and public awareness

Various activities, such as workshops and training at national and regional levels especially on taxonomy, species identification, landing data collection and data analysis, biology, genetics, among others were organized by MFRDMD with the objective to enhance human resources in the SEAFDEC Member Countries in elasmobranch taxonomy and biology as well as ensure the capability of all participants on technique in data collection of sharks and rays up to species level.

In addition to capacity building on data collection on sharks and rays, starting 2021, MFRDMD in collaboration with Universiti Malaysia Terengganu also introduced another approach by monitoring parasites which play a crucial part in understanding species endemicity and if the population is more susceptible to certain environmental ques due to the presence of certain parasite species. A workshop on conservation of sharks and rays through parasites perspective was organized in 2021. It is expected that the information derived from parasite monitoring would contribute to better conservation and management of the population of these species groups in the future.

Consultations and campaigns with stakeholders have also been conducted occasionally, especially in Malaysia, to raise awareness of the importance of sustainable conservation and management of sharks and rays. This included a campaign to release juvenile sharks and rays caught by monsoon coastal trawlers in 2019–2020. Posters of updated list of protected species in Malaysia including actions to be taken if any of species are unintentionally caught was published by MFRDMD and distributed to all stakeholders and the DOF Malaysia. All fishers in the State of Sabah were also advised to display the poster on their fishery vessels.

Way Forward

MFRDMD will continue to implement projects on sharks and rays especially on landing data collection by species at major landing sites, workshops and trainings on taxonomy and biology, study on genetic population structure of selected species, and marketing and trade surveys at selected areas. Moreover, MFRDMD is looking forward to expanding the scope to study the population of sharks and rays at selected areas through the parasites' perspective.

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