JIPK. Volume 13 No 1. April 2021
Sinta 2 (Decree No: 10/E/KPT/2018)
e-ISSN:2528-0759; p-ISSN:2085-5842
DOI=10.20473/jipk.v13i1.24703
Available online at https://e-journal.unair.ac.id/JIPK/index

JIPK
(JURNAL ILMIAH PERIKANAN DAN KELAUTAN)

Review Article

A Review on Ray Capture According to Fishing Gear Worldwide

Nur Arina Hayati Mohidin[1], Sukree Hajisamae[3], Mazlan Hashim[4], Nik Aziz Nik Ali[1] and Mohd Fazrul Hisam Abd Aziz[1,2]

[1]Faculty of Fisheries and Food Sciences, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu Malaysia
[2]Higher institution Centre of Excellence (HICoE), Institute of Tropical Aquaculture and Fisheries, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia
[3]Prince of Songkla University, Faculty of Science and Technology, Pattani, 94000 Thailand
[4]Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor Darul Takzim Malaysia

ARTICLE INFO

Received: January 05, 2021
Accepted: March 05, 2021
Published: March 31, 2021

*) Corresponding author:
E-mail: md.fazrul@umt.edu.my

Keywords:
Stingray
Gillnets
Artisanal Fishery
Bycatch
Malaysia

Abstract

A coral reef is one of the important ecosystems. However coral Gillnets are usually used as a fishing gear by an artisanal fishery in Malaysia. This gear is commonly used by most countries. This paper discussed the rays capture worldwide by using a variety of fishing gear and also bycatch issues that commonly happen. The efficiency of the fishing gear used in capture ray species is compared and discussed among the countries. This paper distinguishes the maturation size for the female and male ray according to the species presence. The bycatch scenario is also discussed as the majority of this elasmobranch (shark and ray) which is caught as bycatch in both small-scale fisheries (gill nets, long lines and hooks) and large-scale fisheries (bottom trawl and purse seine). This paper explains the suitable type of fishing gear to use to capture ray species in a particular country.

Cite this as: Mohidin, N. A. H., Hajisamae, S., Hashim, M., Ali, N. A. N., & Abd Aziz, M. F. H. (2021). A Review on Ray Capture According to Fishing Gear Worldwide. *Jurnal Ilmiah Perikanan dan Kelautan*, 13(1):68–82. http://doi.org/10.20473/jipk.v13i1.24703

1. Introduction

Gillnets are one of the passive fishing gears that is used in fishing worldwide. Gillnets are defined as the fishing net that hung vertically in the water so that the targeted fish will be trapped by their gills. In most of the countries, the gillnet gear is also highly variable. Gillnets can be set on the surface, mid-wateror bottom by anchored or left drifted or connected to the vessel, depending on the species targeted. Moreover, several types of mesh size of nets may be combined into one fishing gear. Normally, the mesh size of nets, netting position and soaking time are important to decide the gillnets efficiency. Moreover,those elements can change depending on the target species (Holst *et al.*, 1998; Rueda, 2008). The location of deployment is varied according to the target species, from pelagic fishes to nearshore water to capture coastal fishes (Bjordal, 2001; Rueda, 2008). Generally, mesh sizes of gillnets used in Malaysia water are 18 cm and 16 cm which catch high diversity of fish and bycatch. The appropriate soaking time for gillnets is less than a day depending on the area placed. Even though it gives a lot of catches, gillnets designation has impacted to incidental catch of endangered species such as turtle, sharks, and marine mammals in certain areas (Rueda, 2008).

The production of fisheries catches trends are almost stagnant and so it is required to harvest unexploited oceanic fish resources. The world marine capture production has decreased by 6% whereas Malaysian production has increased by 16%. The estimated Catch Per Unit Effort (CPUE) of artisanal fishery in Malaysia has decreased from 40 (2001) to 29 tons/vessels(2007). It shows that stocks in Malaysia as well as in the world have been decreasing over the years (Chowdhury and Yahya, 2012). Global capture fisheries production had reached 96.4 million tons in 2018, this increase was mostlydriven by marine capture fisheries. Based on a long-term monitoring assessment, the state of marine fishery resources has continued to decline (FAO, 2018). The stingrays have become a major component of commercial fisheries around the world due to a high demand from the market. Malaysia was ranked eighth in the world, for stingrays and sharks landing with a contribution of 1.2% of the world (FAO, 2016). The demand of stingrays in Malaysia every year remains constantat 10,000 metric tons despite the fluctuation each year. The total landing is 12,281, 13,311, 11,993, and 11,590 metric tons from 2016 to 2019 (DOF, 2016; DOF, 2017; DOF, 2018; DOF, 2019). Wide range of gears are used for stingrays' fisheries such as gillnetsand bottom trawls (Ahmad *et al.*, 2004). The fisheries for rays are common in the world and they differ in species, type of fishing gear, and the vessel used.

The diversity makes it difficult to study the problems involved in collecting accurate data on yields and fishing efforts. The cases are lack of information due to unreported data. The statistical analysis for rays and shark around the world needs to be improved so thatthe status of the stocks will be known.

There are over 800 species of elasmobranch fishes (Figure 1), most sharks, skates, and rays in world's ocean marine ecosystem including 450 species from Rajiformes order which also include skates and ray (Krogh and Reid 1996; Cain *et al.*, 2004). Rays, as the most common bycatch group, have been recorded in New South Wales shark meshing catches (Krogh and Reid, 1996). Elasmobranch fishes have a wide range of reproductive strategies towards the diversity of morphological and physiological specializations (Maruska *et al.*, 1996). The information about elasmobranch reproductive activity remains undescribed for the majority of the species(Maruska *et al.*, 1996). Most of the studies used the gonadosomatic index (GSI) to determine reproductive activity based on the relationship between relative gonad size and mating season. GSI functions well to show the changes in testicular size but it does not providean estimate mating activity of the species (Maruska *etal.*, 1996). Histology used to show the changes in gonad structure of species studies upon reproductive activity, and periodicity can be determined.

Stingrays are flat fish with dorsoventral shape and equipped with strong mouth which efficiently crush the food items such as crustaceans and mollusks(Motta and Huber, 2004) (Figure 2). They are able to emigrate from one habitat to another with their muscular wings and aerodynamically cruise over long distances. Stingrays are commonly found in shoal. Stingrays commonly "fly" along with underwater currents. They remain motionless, swim backwards, and can be found on the surface to the middle of water column when hunting pelagic fish. Stingrays camouflage themselves by burying their flat bodies, except for eyes, into soft sand or muddy sediment of either sea or river when hunting preys (Camhi *et al.*, 1998, Wetherbee and Cortés, 2004). They can attack with their dorsal spine tails whenever they feel threatened.

There are 20 families, 65 genera, and around 621 species of rays recorded in the world (Compagno, 1999). Stingrays consist of four subfamilies; Dasyatinae, Neotrygoninae, Urogymninae, Hypolophinae, and other 89 species which are currently recognized around the world (Last *et al.*, 2016). Pelagic stingray is known as the globally subtropical and tropical pelagic water species (Verasetal., 2009; Weidner, 2014). It inhabits both benthic and pelagic water whichis known as benthopelagic (Neer, 2008). Stingrays are commonly found in deeper water only (approximately 4000 m deep) (Weidner, 2014).

Kingdom: Animalia
Phylum: Chordata
Subphylum: Vertebrata
Superclass: Gnathostomata
Class: Chondrichthyes
Subclass: Elasmobranchii
Order: Rajiformes, Torpediniformes, Myliobatiformes, Pristiformes, Rhinobatiformes

Figure 1. Taxonomic hierarchy of elasmobranch (Myers et al., 2021; https://www.elasmodiver.com/elasmobranch_taxonomy.htm)

The stingray sexes are defined by the presence of the clasper (Figure 2). If the clasper is present, it is a male stingray. The biological research conducted on the pelagic stingrays stated that stingrays are sexual dimorphic. That means the female size of the individual tends to reach adultsize faster than the male. The maturation size respectively is39 cm for female and 37 cm for male (Weidner, 2014).

Dasyatis violacea is a pelagic stingray which almost exists worldwide in subtropical, tropical seas, and also atthe temperate latitude area (Mollet, 2002). *D.violacea* is arelatively small ray with a maximum Disc Width (DW) of800 mm, caught as bycatch on longlines for swordfish, and tuna (Mollet, 2002). *Dasyatis sabina*, the Atlanticstingray, is the most plenteous and geographically dispersed elasmobranch in southeastern estuarine water of the United States (Maruska *et al.*, 1996). The Dasyatidae family can be differentiated by an external characteristic of their body which is variably depressed with a well-formed oval, circular or rhombic disc that fully incorporates the head. Male and female Atlantic stingrays mature at 190 mm Disc Width (DW) and 220 mm DW respectively (Maruska *et al.*, 1996).

Dasyatis americana is a common stingray in tropical and subtropical water of the Western Atlantic, including the Gulf of Mexico and the Caribbean Sea (Henningsen, 2000). Male and female southern stingrays mature at 510 mm Disc Width (DW), and 750–800 mm DW respectively (Henningsen, 2000). *Leucoraja ocellata*, the winter skate from family Rajidae, is endemic to inshore water of the western North Atlantic from Newfoundland Banks, and the Southern Gulf of St. Lawrence in Canada to North Carolina inthe USA. Mature male skates could reach 750 to 960 mm total length (TL) while mature female skates ranged from 735 to 940 mm TL (Sulikowski *et al.*, 2004). Maskray species (*Neotrygon picta*, *Neotrygon annotate* and *Neotrygon kuhlii*), which belongs to small genus within Myliobatiformes order, Dasyatidae family, is caught in northeast Australia (Jacobsen and Bennett, 2010).

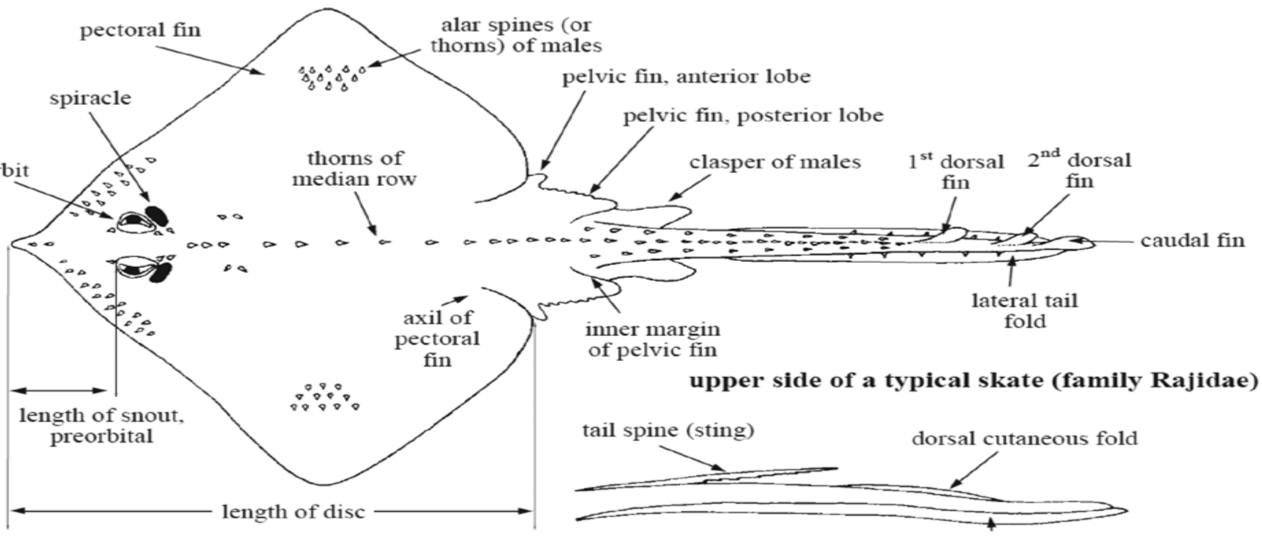

Figure 2. External anatomy of a male stingray (Nair & Zacharia, 2015)

Himantura uarnak, the honeycomb stingray, is widely distributed in the Indo-Pacific and also reported in southeastern Africa and Red Sea (Ali *et al.*, 2013). *Pteroplatytrygon violacea*, the pelagic stingray, is oceanic epipelagic species that inhabits along the continental shelves and island (Ferrari and Kotas, 2013). The maximum range of Disc Width (DW) for *Pteroplatytrygon violacea* was 800 mm (Ferrari and Kotas, 2013).

Total of 472 *Rhinobatos jimbaranensis* were caught in Indonesia, contained 160 female, 118 male and the rest were not sexed. The female sizeranged from 491 to 994 mm while male was from 506 to 953 mm. Furthermore, a total of 891 of *Rhinobatus penggali* were reported with 342 female, 351 male and the rest were not sexed. This species size ranged from 492 to 992 mm for female and 452 to 864 mm for male. Both of the species are from family Rhinobatidae. Moreover, ray's species from family Rhynchobatidae in Indonesia water was *Rhynchobatus australiae*. The female species size ranged from 460 to 3000 mm and male from 515 to 1900 mm (White and Dharmadi, 2007). The family Gymnuridae consist of two species that have been recorded in Indonesian water which are *Gymnura japonica* and *Gymnurazonura*. The range size for female *Gymnura japonica* is 222 to 1080 mm W_D as for male range is 210 to 650 mm W_D. The data was inadequate to determine the size of maturity for this species. For *G.zonura*, female and male size ranged from 491 to 994 mm, and 506 to 953 mm W_D, respectively (White and Dharmadi, 2007).

Dasyatidae is the most common family that often found in Asian water. According to this study, several species of Dasyatidae were recorded in Indonesian water. A total of 12,122 *Dasyatis cf.kuhlii* (Java form) were recorded, consisted of 283 female, 191 male,and 11,638 were not sexed. The size for female isfrom 118 to 379 mm and male from 128 to 324 mm W_D, respectively. A total of 964 *Dasyatis cf.kuhlii* (Baliform) were reported, 84 female, 75 male, and 805were not sexed. The size of female ranged from 240 to 471 mm and male from 172 to 450 mm W_D, respectively. Furthermore, a total of 49 *Dasyatis cf.ushiei* were reported with the female size rangedfrom 729 to 2020 mm W_D, and male ranged from 629 to1624 mm W_D. Other species were also recorded in this study with a total of 4,222. The measured size for the female was 104 to 287 mm and the male was 92 to 245 mm W_D (White and Darmadi, 2007).

2. Rays Capture According to The Types of Fishing Gear Worldwide

In 2016,Asia makes up 85% of the global population engaged in fisheries and aquaculture sectors. The sum up of fishing vessels worldwide in 2016, from small undecked and non-motorized boats to larger commercial industrial vessels, were estimated around 4.6 million. Asia was the largest to contribute in 3.5 million (75%) vessels accounting for the global fleet (FAO, 2018). Bangladesh, Myanmar, and Sri Lanka represented 50% of the total vessel used in Asia including motorized and non-motorized vessels, but other countries such as Europe, Latin America, the Caribbean, and Oceania, in major used motorized vessels (FAO, 2018). The fishing gear is classified into two types which are commercial and traditional fishing gear. The commercial fishing gears are trawl, purse seine, driftnet, and gillnets while the traditional fishing gears are hook and line, lift net, and traps. However, the fishing gears which contribute to the landings are mostly trawl, purse seine, drift net, and also gillnets. The total of world marine capture was 81.2 (2015) and 79.3 million tons (2016) showed a declination of almost 2 million tons. Malaysia had 1,574,443 tons of production in 2016 which increased rapidly in the past two years (FAO, 2018).

Afonso *et al.* (2012) research was conducted by using pelagic longline with baited hook targeting swordfish (*Xiphias gladius*) and tuna fish at southwestern equatorial Atlantic. This study was conducted to discuss the influence of hook type (circle and J-hook) on longline catch, and mortality target as well as bycatch species. As a result, a total of 603 individuals were caught and 317 (53%) were classified as bycatch. Forty five percent of the bycatch was constituted by sharks and the rest are swordfish, bigeye tuna, blue shark, common dolphinfish, and pelagic stingray. In western Atlantic Ocean, they used pelagic longline in fishery targeting for swordfish *(Xiphius gladius*), yellowfin tuna (*Thunnus albacares),* and bigeye tuna (*Thunnus obesus*), but as a result, many shark species such as bigeye thresher (*Alopias superciliosus*), blue (*Prionace glauca*), dusky (*Carcharhinus obscurus*), longfin mako (*Isurus paucus*), night (*Carcharhinus signatus*), oceanic whitetip (*Carcharhinus longimanus*), porbeagle (*Lamna nasus*), sandbar (*Carcharhinus plumbeus*), scalloped hammerhead (*Sphyrna lewini*), shortfin mako (*Isurus oxyrinchus*), silky (*Carcharhinus falciformis*), and tiger (*Galeocerdo cuvier*) were caught as bycatch species and only 3431 swordfish and 1596 tuna were caught as target species (Gallagher *et al.*, 2014).

Pelagic longline with the baited hook (J-hook and circle hook) was normally used to target swordfish and tuna in the Atlantic Ocean. Afonso *et al.* (2011) study was conducted at the coast of Natal, Northeast Brazil by using pelagic longline with baited hook of skipjack (*Katsuwonus pelamis)* to examine the influence of the gear modification on bycatch and mortality of elasmobranch caught. Another research was conducted in Northeast Brazil but in a different area which was at the Coast of Recife. Bottom longline with baited hook of moray eel *(Gymnothorax sp.)* was used to target swordfish and tuna. As a result, the catch for pelagic longline undergoes declination of tuna catches and the night shark (*Carcharhinus signatus*), and the blue shark (*Prionace glauca*) were the most common shark species caught, comprising 48.5% of the total shark known as by catch, followed by the silky shark, (*Carcharhinus falciformis*) (10.4%), the oceanic white tip (*C. longimanus*) (9.0%), the scalloped hammerhead (*Sphyrna lewini*) (8.2%), the dusky shark (*Carcharhinus obscurus*) (7.4%), the tiger shark (*Galeocerdo cuvier*) (6.0%), the nurse shark (*Ginglymostoma cirratum*), the shortfin mako (*Isurus oxyrinchus*) (both with 4.4%), and the bull shark, (*Carcharhinus leucas*) (1.5%). Meanwhile for bottom longline, 46 rays and 63 sharks were represented by nine species and caught which are *Dasyatis americana* (39.5%), *Carcharhinus acronotus* (37.6%), *Ginglymostoma cirratum* (12.8%), *Galeocerdo cuvier* (3.7%), *Manta birostris* (2.7%), *Carcharhinus leucas* (1.8%), *Sphyrna lewini* (0.9%), and *Carcharhinus limbatus* (0.9%). Coelho *et al.* (2012) research study aimed to test hooking mortality in a pelagic longline fishery with baited hook of squid (*Illex* spp.) and mackerel (*Scomber* spp.) targeting swordfish inthe Atlantic Ocean and bycatching pelagic sharks. The most elasmobranch bycatch result caught are 30,168 of blue shark (*Prionace glauca*), 396 of pelagic stingray (*Pteroplatytrygon violacea*), 310 of silky shark (*Carcharhinus falciformis*), 281 of Oceanic whitetip shark (*Carcharhinus longimanus*), 145 of Mantas and devil rays (Mobulidae) and 19 of Eagle rays (Myliobatidae). The previous study was conducted by Ferrari and Kotas (2013) in Southeast and South Brazil used surface longline with baited hook of Squid (*Illex* sp.) and light (*Lumi*). The aim of this study was related tothe hook selection between circle hook and J-hook in reducing bycatch by using pelagic longline. As a result, *Pteroplatytrygon violacea* caught by using J-hook (36-58 cm DW) was larger compared to circle hook (34-50 cm). This shows that the circle hook is more effective in reducing the *Pteroplatytrygon violacea* bycatches (Ferrari and Kotas, 2013).

In the Western and Central Pacific Ocean, a research was conducted to compare the operational details and t o i d e n t i f y t h e rates between experimental longlines with no-shallow hooks and control sets targeting bigeye tuna (Beverly *et al.*, 2009). From said study, many elasmobranch species were caught such as pelagic stingray (*Pteroplatytrygon violacea*), blue shark (*Prionace glauca*), shortfin mako (*Isurus oxyrinchus*), oceanic whitetip (*Carcharhinus longimanus*),andbigeye thresher (*Alopias superciliosus*).

In the central Mediterranean Sea, one research has conducted to examine the importance of longline gear modification which influences the bycatch rate of pelagic stingray. The Mediterranean Sea is one of the regions which have fishing ground for swordfish (Piovano *et al.*, 2010). In this study shows that the longline fishing vessels target pelagic fish (swordfish), but total of 222 pelagic stingrays arecaptured.

The previous study by Coelho *et al.*, (2011) had been examining the at-haulback fishing mortality of elasmobranch caught by Portuguese longliners that target swordfish in Indian Ocean. The most abundant capture from the study is a blue shark (81.1%), followed by the shortfin mako (14.8%), other species such as pelagic stingray, and manta rays (Coelho *et al.*, 2011).

In the Gulf Stream inshore, one study had been conducted by using survey trawl of sea turtle to identify blood chemistry and hematology value for dasyatid stingrays (Cain *et al.*, 2004). The result from this study caught southern stingrays (*Dasyatis Americana*) as bycatch from a trawl survey for sea turtle species, while live rays were caught aboard from independent fishery boats.

Another study was conducted at Fitzroy River, WesternAustralia to identify the movement of freshwater elasmobranch and to compare the seasonal change in relative abundance of each species from three sampling site in the lower, middle, and upper reaches of the river (Thorburn *et al.*, 2004). Sixty eight elasmobranchs from three species were caught which were *P.microdon, C. leucas* and *P. clavate*. *Pristis microdon* was the most abundant species (21 individuals) caught both in lower and middle river while *Pristis clavata* was the second most abundant species (Thorburn *et al.*, 2004). From the comparison above showed that during late drought, reduction in abundance of the species in both lower,and middle reaches happen.

This past research was done in the Marajo Island, the mouth of the Amazon River using bottom longlines with a baited hook, beach trawl nets, and hand-lines and also traps as various fishing gear to study the relationship between the freshwater stingray species composition, abundance, and the different habitats characteristics (Almeida *et al.*, 2009). The efficiency of the fishing gear is varied as longlines caught 90% of stingrays while traps caught 56% of the stingrays in the regions with tidal influence. Bycatch species which was captured from this study was mainly small catfish

Indonesia has the highest diversity of elasmobranch in the world which includes rays and sharks and their fishery production increases annually (Dharmadi *et al.*, 2009; Fahmi, 2010). Elasmobranch is mostly caught by coastal artisanalfisheries (gillnets, trammel nets, purse seine, longlines, and droplines) and also as bycatch in commercial shrimp trawlers and pelagic tuna fisheries (Dharmadi *etal.*, 2009). The dominant species of rays is Dasyatidae from overall 34 % rays from small to large size (White and Dharmadi, 2007; Dharmadi *et al.*, 2009; Iqbal *et al.*, 2018; Windusari and Iqbal, 2018).

The previous study was conducted, mobulids rays were commonly caught as bycatch by using surface gillnet, longline, purse seine, and directed harpoon, but the details were poorly documented by fisheries management (White *et al.*, 2006). In Indonesia, mobulids rays are caught as bycatch species by artisanal gillnet fishers that targeting for skipjack tuna *(K.pelamis)*. The most abundant mobulid ray's species are, *Mobula japonica*, *Mobula tarapacana*, *Mobula birostris*, *Mobula thurstoni*, and *Mobula* cf. *kuhlii* (White *et al.*, 2006).

From the previous study in Malaysia, three types of fishing gear which are barrier net, gillnet, and beam trawl have been used in catching stingray in coastal mud flat in Kuala Selangor to determine the length-weight relationship (Lim *et al.*, 2014). Total of six species of stingrays were sampled from this study which were H. *walga*, *D. bennetti*, *D. zugei*, *Neotrygon kuhlii*, *Taeniura lymma*, and *Himantura pastinacoides.* The largest collected stingray was *Dasyatis bennetti* with a size of 53.1cm DL (Lim *et al.*, 2014).

According to Krajangdara, Thailand's marine production was harvested from the Gulf of Thailand, and the Andaman Sea. Ninety percent of the production was caught by commercial fishing gears and others by small scale fishing gears. Sharks and rays are commonly caught as bycatch species by trawls, purse seine, longlines, gillnets, and also otter board trawl. There were 11 families and 71 species of rays reported in 2004-2014 (Krajangdara, 2014). Based on Vidthayanon research, the most common ray species are from family Dasyatidae (whiptail stingray) followed by Rhinidae (Wedgefish), and also Myliobatidae (Eagle ray). From previous research, one survey had been conducted for species diversity of the South China Sea fishes and was carried out in the Gulf of Thailand, and EastMalay Peninsula by using otter board bottom trawl nets. The result from this research obtained around 13 orders, 34 families, and 149 species of elasmobranch mainly from coastal habitats (Vidthayanon, 1999).

In Cambodia, sharks and rays have not been studied in detail as other living resources. In Cambodia water, only 20 species of sharks, and 22 species of rays have been studied (Try *et al.*, 2004). Several types of fishing gear such as gillnets, longlines, grouper net, and demersal or bottom trawls have been used in the fishery industry in Cambodia. However, sharks and rays are normally caught as bycatch species. The rays caught are from family Rhinobatidae, Rhynchobatidae,Dasyatidae, Gymnuridae, Myliobatidae, and Mobulidae (Try *et al.*, 2004).

Previous research had conducted a survey by using midwater trawl along the northeastern Philippines with around 35 stations with the depth of water reached 4667 m. The result captured was Chondrichthyes (Compagno *et al.*, 2005). Someof the elasmobranchs had been a list in IUCN Red List (2003) such as *Aetobatus narinari* (Spotted eagle ray), *Aetomylaeus nichofii* (Banded eagle ray), and *Glaucostegus types* (Giant shovelnose ray) (Compagno *et al.*, 2005). However, this survey does not explain the fishing gear characteristic details as its focus on the conservation of the Chondrichthyes in the Philippines.

Recently, China has recorded around 13 species of family Dasyatidae from both marine and freshwater. *Dasyatis akajei* is a stingray which lives in freshwater, and migrates along West River to Nanning, while the remaining species are from marine habitat. The new record specimen of Dasyatidae found is *Dasyatis laosensis* (Chen *et al.*, 2010). Most of the previous study in China does not mention thefishing gear used to catch or collect ray species.

The richest and diverse chondrichthyan faunas in the world out of five countries is Taiwan with at least 181 known species. Taiwan ranking behind Australia (322 species), Southern Africa (220 species), Japan (212 species), and very close to the Western Central Atlantic (188 species) because other areas, however, embrace a much greater geographic dimension than the seas surrounding Taiwan; for its geographic area, no other equivalent region has a chondrichthyan fauna is diverse (Ebert *et al.*, 2013). Taiwanese water represents about 15% of the known species with 119 sharks, 58 batoids, and four chimaera species. The most abundant species of rays in Taiwanese water is from family Rajidae and Dasyatidae, and it is due to the complexity of habitats, and ocean currents of the waterregions. The two ocean current flow patterns give influence on the marine biodiversity of the Taiwanese water regions (Ebert *et al.*, 2013). Mostly the specimen collected was using commercial bottom trawlers (Shao *et al.*, 2008), and shrimp trawl fisheries (Straube *et al.*, 2013). From the previous study conducted by Hsu *etal.* (2013), the specimens collected were caught using deep-sea longline, and also bottom trawl in the water off northeastern Taiwan (Table 1). The ray specimens caught are *Notoraja tobitukai* (Leadhued skate), *Dipturus gigas* (Giant skate), and *Pteroplatytrygon violacea* (Pelagic stingray). Those rays are unexpectedin Taiwanese water and often caught as bycatch (Straube *et al.*, 2013) or as trash fish without any further identification (Hsu *et al.*, 2013), the specimens collected were caught using deep-sea longline, and also bottom trawl in the water off northeastern Taiwan (Table 1). The ray specimens caught are *Notoraja tobitukai* (Leadhued skate), *Dipturus gigas* (Giant skate), and *Pteroplatytrygon violacea* (Pelagic stingray). Those rays are unexpectedin Taiwanese water and often caught as bycatch (Straube *et al.*, 2013) or as trash fish without any further identification (Hsu *et al.*, 2013).

Table 1. Summary of fishing gear used worldwide

References	Area	Type of gear used	Species collected		Remarks
			Targeted	Bycatch	
Afonso *et al.*, 2012	South-western equatorial Atlantic	Pelagic longline with baited hook	Swordfish (*Xiphias gladius*) and tuna fish	Sharks, bigeye tuna, *Thunnus obesus*, blue shark, common dolphinfish, *Coryphaena hippurus*, and pelagic stingray	
Gallagher *et al.*, 2014	Western Atlantic ocean	Pelagic longline	Swordfish (*Xiphius gladius*), yellowfin tuna (*Thunnus albacares)* and bigeye tuna (*Thunnus obesus*)	Shark species such as bigeye thresher (*Alopias superciliosus*), blue (*Prionace glauca*), dusky (*Carcharhinus obscurus*), longfin mako (*Isurus paucus*), night (*Carcharhinus signatus*), oceanic whitetip (*Carcharhinus longimanus*), porbeagle (*Lamna nasus*), sandbar (*Carcharhinus plumbeus*), scalloped hammerhead (*Sphyrna lewini*), shortfin mako (*Isurus oxyrinchus*), silky (*Carcharhinus falciformis*), and tiger (*Galeocerdo cuvier*)	
Afonso *et al.*, 2011	Natal, north-east Brazil	Pelagic longline with the baited hook	Swordfish and tuna	Silky shark, (*Carcharhinus falciformis*), the oceanic white tip, (*C. longimanus*), the scalloped hammerhead, (*Sphyrna lewini*), the dusky shark, (*Carcharhinus obscurus*), the tiger shark, (*Galeocerdo cuvier*), the nurse shark, (*Ginglymostoma cirratum*),the shortfin mako, (*Isurus oxyrinchus*) and the bull shark, (*Carcharhinus leucas*)	
	Coast of Recife	Bottom longline with baited hook	Swordfish and tuna	*Dasyatis americana*, *Carcharhinus acronotus*, *Ginglymostoma cirratum*, *Galeocerdo cuvier*, *Manta birostris*, *Carcharhinus leucas*, *Sphyrna lewini* and *Carcharhinus limbatus*	

Coelho *et al.*, 2012	Atlantic ocean	Pelagic longline fishery with baited	Swordfish	Pelagic shark, sblue shark, silky shark, Oceanic whitetip shark, Mantas, devil rays and Eagle rays	
Ferrari and Kotas, 2013	Southern and south brazil	Surface longline with baited hook	*Pteroplatytrygon violacea*, sharks, tunas and swordfish	Smaller size of stingray *Pteroplatytrygon violacea*	
Wallman and Bennet, 2006	St. Joseph's bay, gulf County, Florida	Landing nets	Atlantic stingrays, *Dasyatis sabina*	None	Focused more to biological aspect rather than the fishing gear used
Beverly *et al.*, 2008	Western and central Pacific ocean	Longlines with no-shallow hooks and control sets	Bigeye tuna	Pelagic stingray (*Pteroplatytrygon violacea*), blue shark (*Prionace glauca*), shortfin mako (*Isurus oxyrinchus*), oceanic whitetip (*Carcharhinus longimanus*) and bigeye thresher (*Alopias superciliosus*)	
Piovano *et al.*, 2010	Central mediterranean sea	Longline gear	Swordfish	Pelagic stingrays	
Coelho *et al.*, 2011	Indian ocean	Portuguese longliners	Swordfish	Blue shark shortfin mako, pelagic stingray and manta rays	
Cain *et al.*, 2004	Inshore of the gulf stream	Survey trawl of sea turtle	None	Southern stingrays (*Dasyatis americana*)	Focused to study blood chemistry and haematology value for dasyatid stingrays
Thorburn *et al.*, 2004	Fitzroy river, western Australia	Gill net set	Freshwater elasmobranch, *P.microdon*, *C. leucas* and *P. clavata*	None	Focused on comparing the seasonal change in relative abundances
Almeida *et al.*, 2009	Marajo island	Bottom longlines with a baited hook, beach trawl nets and hand-lines	Freshwater stingray species	Small catfish	

Dharmadi *et al.*, 2009	Indonesia	Trawlers, gillnets, trammel nets, purse seine, longlines and droplines	Shrimp and tuna	Rays and sharks	
White *et al.*, 2006	Indonesia	Artisanal gillnet	Skipjack tuna (*K.pelamis)*	Mobulids rays	
Lim *et al.*, 2014	Malaysia	Barrier net, gill net and beam trawl	Stingrays	None	Focused on length-weight relationship of stingray species
Krajangdara, 2014	Thailand	Trawls, purse seine, longlines, gill nets and otter board trawl	None	Sharks and rays (Dasyatidae, Rhinidae and Myliobatidae)	Status of sharks and rays by marine fishery
Vidthayanon, 1999	Thailand	Otter board bottom trawl nets	None	Species of elasmobranch	
Try *et al.*, 2004	Cambodia	Gill nets, long lines, grouper net and demersal or bottom trawls	None	Sharks and rays (Rhinobatidae, Rhynchobatidae, Dasyatidae, Gymnuridae, Myliobatidae and Mobulidae)	Review of National Management Activities in Cambodia
Compagno *et al.*, 2005	Philippines	Midwater trawl	None	Species of elasmobranch such as *Aetobatus narinari Aetomylaeus nichofii* and *Glaucostegus types*	Report on checklist of Philippine chondrichthyes
Chen *et al.*, 2010	China	Not mention about fishing gear used	*Dasyatis laosensis*	None	A new record specimen of Dasyatidae species in China
Ebert *et al.*, 2013	Taiwan	Not mention	Chondrichthyans: Batoid (Rajidae and Dasyatidae)	None	Focused on data of biodiversity of sharks, rays, and chimaeras (Chondrichthyes) of Taiwan
Shao *et al.*, 2008	Taiwan	Bottom trawlers	Marine fishes ncluding deep-sea fishes	None	Purpose to compile a species checklist and new fish records.

Straube *et al.*, 2013	Taiwan	Shrimp trawl fisheries	Chondrichthyan diversity	None	Present an analysis of the molecular data of the Taiwanese chondrichthyan
Hsu *et al.*,2013	North-eastern Taiwan	Deep-sea longline and bottom trawl	Rajidae and Dasyatidae	*Notoraja tobitukai* (Leadhued skate), *Dipturus gigas* (Giant skate), and *Pteroplatytrygon violacea* (Pelagic stingray	

3. Bycatch Issues

Most significant scenario affecting fisheries management nowadays is bycatch (Hall *et al.*, 2000). The main environmental impact of fisheries industry is happening through bycatch (Shester and Micheli, 2011). The causes of depletion of marine species including elasmobranch are caused by unregulated overfishing, destructive fishing, and environmental degradation caused by human activities (Chowdhury and Yahya, 2012). The biggest challenges in fisheries research are reducing the bycatch of unwanted species and the incidental species taken (Gallagher *et al.*, 2014; Oliver *et al.*, 2015). It can be a major driver for marine species decrease (Moore *et al.*, 2010; Vaudo, 2011; Coelho *et al.*, 2015) and a major threat to over 70% of elasmobranch species around the world (Gallagher *et al.*, 2014). It is important to understand the habitat and ecology of the species targeted (Vaudo, 2011). Most elasmobranchs have a slow growth rate, low reproductive potential rate, and also high age maturity which lead to slow recovery when the decline in population dueto bycatch or mortality. The data of ray population which have been documented are fewer compared to the shark population (O'Shea, 2012).

Elasmobranch (shark, skates, and rays) are the incidental fishing mortality of species with the low reproduction rates respectively (Afonso *et al.*, 2011; Oliver *et al.*, 2015). Elasmobranch is the top-level predator in marine ecosystem even though their abundance is commonly smaller compared to lower trophic level, and any changes can affect biodiversity (Hall *et al.*, 2000; Vaudo, 2011; Afonso *et al.*, 2011). However, their existence is very important to the marine ecosystem widely. Incidental mortality of sea turtle, sharks, rays, and teleost in longline fisheries is one of the major threats for many of these species (Afonso *et al.*, 2011; Shester and Micheli, 2011). Elasmobranchs in particular are having a drastic declination of the population across their range (Baum *et al.*, 2003; Dulvy *et al.*, 2008; Ferretti *et al.*, 2010; Gallagher *et al.*, 2014). Elasmobranch bycatch is rarely reported at the species level in official fishery statistics or often not reported at all (Oliver *et al.*, 2015). The damage of benthic structures in the marine habitat is because of some types of fishing gears such as bottom trawling (Shester and Micheli, 2011). Normally, the pelagic stingray such as *Pteroplatytrygon violacea* is one of the bycatch species in commercial purse seine and pelagic longline fisheries in the world (Weidner, 2014).

Gear modifications related to the fishing gear could overcome bycatch issues by decreasing the number of unwanted species. It may be the effective and inexpensive tools in reducing non-target species mortality (Afonso *et al.*, 2011). Non-targeted species are grouped into two categories which are incidental and bycatch (Afonso *et al.*, 2011; Shester and Micheli, 2011). The magnitude and composition of bycatch are alsoinfluenced by the selectivity of the fishing gear along with the fishing effort. Gillnets and longlines are considered as more selective fishing gear than trawl nets asits changes in mesh and hook size which usually have a larger effect on species and size composition (Oliver *et al.*, 2015). The important variables to consider in gear modifications to reduce bycatch are hook shape, hook size, bait type, gear depth, type of light attractor (Piovano *et al.*, 2010), time of longline set and retrieval, and fishing location (Huang *et al.*, 2016). Increased fishing gear visibility through multifilament lines can reduce the catch of pelagic species (Godin *et al.*, 2013). Pelagic stingray (*Pteroplatytrygon violacea*) is commonly known as bycatch species which means it is discarded because of they either have no commercial value or because they are protected as endangered species (Beverly *et al.*, 2009). The previous study has b e e n conductedin the Mediterranean to evaluate the importance ofgear modification used in influencing the bycatch rate of pelagic stingray such as *P. violacea* (Piovano *et al.*, 2010).

Bycatch capture of non-target species occurs in a wide range of fisheries including trawl gear, purse seine, gillnets, and longlines (Huang *et al.*, 2016). Gillnets have high bycatch rate issues compared to other fishing gear, which in some cases can result in high mortality rates (Rueda, 2008). Other issue related to gillnets bycatch is connecting with artisanal, small scale fisheries which faces the challenges of the collection of data and strategies management (Rueda, 2008). Longline also has caught a huge amountof incidental and bycatch species and has received attention in fisheries management as a priority both domesticallyand internationally (Kersterter and Graves, 2006; Beverly *et al.*, 2009). Although, as stated by Carvalho *et al.* (2015) pelagic longlines are considered as more selective fishing gear compared to trawl and gillnets. The pelagic longline fishery has been known for its significant shark bycatch for a huge percentage of overall total catch (Godin *et al.*, 2013). The fishing mortality on bycatch species from pelagic longline fishing can be minimized or reduce by decreasing the interaction rates or the number of animal dead at haulback (Kersterter and Graves, 2006). From the previous study,the comparison of artisanal fishing gear (set gillnets, drift gillnets, fish traps and lobster traps) have been done to compare the potential impacts in term of their bycatch (Shester and Micheli, 2011).

Indonesia has the largest variety of elasmobranch species in the world. In spite of increasing catches and fishing effort, the catch per unit effort appears to be decreasing in number which proves that the overall abundance of those species is declining (White and Dharmadi, 2007). The data on species and size compositions of species landings are not reported completely although Indonesia has the largest elasmobranch species in the world. Elasmobranch are caught as both target fisheries (tangle nets, longlines, and demersal gillnets) and also bycatch (drift gillnets, trammel nets, longlines, and bottom trawls) according to types of fishing gear (White and Dharmadi, 2007).

4. Conclusion

Malaysia has diverse fishing gear and methods in capturing variety of fishes, however, they still need extra attention about the minimum and maximum size, and the limit for every catch in certain area to ensure the marine production is sustained forthe longest time. Rays capture in Malaysia often uses gillnets as the fishing gear but the capture still has other bycatch species, and the size of rays is not seriously being considered. The variety of fishing gear used by other countries has been compared in catching ray species. Mostly, the capture of rays in other countries are treated as bycatch or incidental catch, not as their main targetspecies. The gillnets need to be modified according to the habitat of ray species target to ensure successful catches.

Acknowledgment

Special thanks to the Ministry of Education for providing grant research for this study FRGS/1/2017/WAB09/UMT/03/5 (No. Vot: 59490) and Universiti Malaysia Terengganu for their support.

Author's Contribution

All authors have contributed to the final manuscript as follows, Fazrul and Nur Arina; studied, wrote, and revised the manuscript. Sukree, Mazlan and Nik; supervised the progress, edited, checked, and corrected the manuscript.

Conflict of Interest

The authors declare that they have no competing interests.

Funding Information

This research supported by the Ministry of Education with grant research number: FRGS/1/2017/WAB09/UMT/03/5 (No. Vot: 59490)

References

Ali, M., Saad, A., Amor, M. M. B., & Capape, C. (2013). First records of the Honeycomb Stingray, *Himantura uarnak* (Forskål, 1775), off the Syrian coast (Eastern Mediterranean) (Chondrichthyes: Dasyatidae). *Zoology in the Middle East*, 49(1):104-106.

Afonso, A. S., Santiago, R., Hazin, H., & Hazin, F. H. V. (2012). Shark bycatch and mortality and hook bite-offs in pelagic longlines: Interactions between hook types and leader materials. *Fisheries Research*, 131-133:9-14.

Afonso, A. S., Hazin, F. H. V., Carvalho, F., Pacheco, J. C., Hazin, H., Kerstetter, D. W., Murie, D., & Burgess, G. H. (2011). Fishing gear modifications to reduce elasmobranch mortality in pelagic and bottom longline fisheries off Northeast Brazil. *Fisheries Research*, 108:336-343.

Ahmad, A., Abdul, H. H., Albert, C. G., Ahemad, S., & Solahuddin, A. R. (2004). Elasmobranch Resources, Utilization, Trade and Management in Malaysia.

Almeida, M. P., Barthem, R. B., Viana, A. S., & Almeida, P. C. (2009). Factors affecting the distribution and abundance of freshwater stingrays (Chondrichthyes: Potamotrygonidae) at Marajó Island, the mouth of the Amazon River. *Pan-American Journal of Aquatic Sciences*, 4(1):1-11.

Baum, J. K., Myers, R. A., Kehler, D. G., Worm, B., Harley, S. J., & Doherty, P. A. (2003). Collapse and conservation of shark populations in the Northwest Atlantic. *Science*, 299:389-392.

Beverly, S., Curran, D., Musyl, M., & Molony, B. (2008). Effects of eliminating shallow hooks from tuna longline sets on target and non-target species in the Hawaii-based pelagic tuna fishery. *Fisheries Research*, 96:281-288.

Bjordal, A. (2001). Chapter 2: The Use of technical measures in responsible fisheries: Regulation of fishing gear. *FAO Fisheries Technical Paper*, 421-424.

Cain, D. K., Harms, C. A., Dipl. A. C. Z. M., & Al Segars, M. S. (2004). Plasma biochemistry reference values of wild-caught southern stingrays (*Dasyatis americana*). *Journal of Zoo and Wildlife Medicine*, 35(4):471-476.

Camhi, M., Fowler, S., Musick, J., Brautigam, A., & Fordham, S. (1998). Sharks and their relatives. Ecology and conservation. IUCN/SSC Shark Specialist Group. IUCN, Gland, Switzerland and Cambridge, United Kingdom, 39 pp.

Carvalho, J. F., Coelho, R., Santos, M. N., & Amorim, S. (2015). Effects of hook and bait in a tropical northeast Atlantic pelagic longline fishery: Part II-Target, bycatch and discard fishes. *Fisheries Research*, 164:312-321.

Chen, Z. M., Zhang, X. Y., Qi, W. L., Li, J. H., & Xiao,

H. (2010). A new record of dasyatid fish in China: *Dasyatis laosensis*. *Zoological Research*, 31(6): 675-676.

Chowdhury, M. A., & Yahya, K. (2012, October). Sustainable seafood production: Malaysian status and comparison with the world. Paper presented at the Conference: International Conference Aquaculture Indonesia (ICAI) -2012, Semarang, Indonesia.

Coelho, R., Lino, P. G., & Santos, M. N. (2011). At-haulback mortality of Elasmobranchs caught on the Portuguese Longline Swordfish Fishery in the Indian Ocean. IOTC–2011–WPEB07–31.

Coelho, R., Carvalho, J. F., Lino, P. G., & Santos, M. N. (2012). An overview of the hooking mortality of elasmobranchs caught in a swordfish pelagic longline fishery in the Atlantic Ocean. *Aquatic Living Resources*, 25:311-319.

Coelho, R., Santos, M. N., Carvalho, J. F., & Amorim, S. (2015). Effects of hook and bait in a tropical northeast Atlantic pelagic longline fishery: Part I-Incidental sea turtle bycatch. *Fisheries Research*, 164:302-311.

Compagno, L. J. V. (1999). General Remarks. In: K. E. Carpenter, V. H. Niem (Eds.), FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Volume 3. Batoid fishes, chimaeras and bony fishes part 1 (Elopidae to Linophrynidae). (pp. 1399-1409). Rome, Italy: Food and Agriculture Organization of the United Nations.

Compagno, L. J. V., Last, P. R., Stevens, J. D., & Alava, M. N. R. (2005). Checklist of Philippine chondrichthyes. CSIRO Marine Laboratories Report, 243:1-103.

Dalzell, P., Adams, T. J. H., & Polunin, N. V. C. (1997). Coastal fisheries in the Pacific Islands. *Oceanographic Literature Review*, 5(44):516.

Dharmadi, Fahmi, & White, W. (2009). Biodiversity of Sharks and Rays in South-eastern Indonesia. Department of Fisheries (DOF), 2016. Perangkaan Perikanan Tahunan, 2015.

DOF. Department of Fisheries (2019). Perangkaan Perikanan Tahunan 2019. Jilid%201/Jadual_Pendaratan_Ikan_Laut_16.xlsx

DOF. Department of Fisheries (2018). Perangkaan Perikanan Tahunan 2018. Jilid%201/4.4_Pendaratan_Ikan_Laut_Mengikut_Negeri_Dan_Spesis_.xlsx

DOF. Department of Fisheries (2017). Perangkaan Perikanan Tahunan 2017. Jilid%201/Jadual_Pendaratan.pdf

DOF. Department of Fisheries (2016). Perangkaan Perikanan Tahunan 2016.

Dulvy, N. K., Baum, J. K., Clarke, S., Compagno, L. J., Cortés, E., Domingo, A., & Valenti, S. (2008). You can swim but you can't hide: the global status and conservation of oceanic pelagic sharks and rays. *Aquatic Conservation Marine and Freshwater Ecosystems*, 18(5):459-482.

Ebert, D. A., Ho, H. C., White, W. T., & Carvalho, M. R. D. (2013). Introduction to the systematics and biodiversity of sharks, rays, and chimaeras (Chondrichthyes) of Taiwan. *Zootaxa*, 3752(1):005-019.

Fahmi. (2010) Sharks and rays in Indonesia. *Marine Resources Indonesia*, 35(1):43-54.

FAO. (2016). The State of World Fisheries and Aquaculture. (2016). Contributing to food security and nutrition for all. Rome. 200 pp.

FAO. (2018). The State of World Fisheries and Aquaculture 2018. Meeting sustainable development goals. Rome. Licence: CC BY-NC-SA 3.0 IGO.

Ferrari, L. D., & Kotas, J. E. (2013). Hook selectivity as a mitigating measure in the catches of the stingray *Pteroplatytrygon violacea* (Elasmobranchii, Dasyatidae) (Bonaparte,1832). *Journal of Applied Ichthyology*, 29(4):1-6.

Ferretti, F., Worm, B., Britten, G. L., Heithaus, M. R., & Lotze, H. K. (2010). Patterns and ecosystem consequences of shark declines in the ocean. *Ecology Letters*, 13:1055-1071.

Gallagher, A. J., Orbesen, E. S., Hammerschlag, N., & Serafy, J. E. (2014). The vulnerability of oceanic sharks as pelagic longline bycatch. *Global Ecology and Conservation*, 1:50-59.

Godin, A. C., Wimmer, T., Wang, J. H., & Worm, B. (2013). No effect from rare-earth metal deterrent on shark bycatch in a commercial pelagic longline trial. *Fisheries Research*, 143:131-135.

Hall, M. A., Alverson, D. L., & Metuzals, K. I. (2000). By-catch: problem and solution. *Marine Pollution Bulletin*, 41:204-219.

Henningsen, A. D. (2000). Notes on reproduction in the southern stingray, *Dasyatis americana* (Chondrichthyes: Dasyatidae), in a captive environment. *Copeia*, 2000(3):826-828.

Holst, R., Madsen, N., Moth-Poulsen, T., Fonseca, P., & Campos, A. (1998). Manual for gillnet selectivity. European Commission, 43.

Huang, H. W., Swimmer, Y., Bigelow, K., & Gutierrez, A. (2016). Influence of hook type on the catch of commercial and bycatch species in an Atlantic tuna fishery. *Marine Policy*, 65:68-75.

Hsu, H. H., Joung, S. J., Ebert, D. A., & Lin, C. Y.

(2013). Records of new and rare elasmobranchs from Taiwan. *Zootaxa*, 3752(1):249-255.

Iqbal, M., Yustian, I., & Zulkifli, H. (2018). The valid species and distribution of stingrays (Myliobatiformes: Dasyatidae) in South Sumatran waters, Indonesia. *Biovalentia: Biological Research Journal*, 4(1):12-20.

Jacobsen, I. P., & Bennett, M. B. (2010). Age and growth of *Neotrygon picta*, *Neotrygon annotata* and *Neotrygon kuhlii* from north-east Australia, with notes on their reproductive biology. *Journal of Fish Biology*, 77:2405-2422.

Kerstetter, D. W., & Graves, J. E. (2006). Effects of circle versus J-style hooks on target and non-target species in a pelagic longline fishery. *Fisheries Research*, 80:239-250.

Krajangdara, T. (2014). Sharks and rays in Thailand. Thailand: Andaman Sea Fisheries Research and Development Center (Phuket) Department of Fisheries.

Krogh, M., & Reid, D. (1996). Bycatch in the protective shark meshing programme off south-eastern New South Wales, Australia. *Biological Conservation*, 77(2-3):219-226.

Last, P. R., Naylor, G. J. P., & Manjaji-Matsumoto, B. M. (2016). A revised classification of the family Dasyatidae (Chondrichthyes: Myliobatiformes) based on new morphological and molecular insights. *Zootaxa*, 4139(3):345-368.

Lim, K. C., Chong, V. C., Lim, P. E., & Yurimoto, T. (2014). Length-weight relationship of stingrays in Kuala Selangor, Malaysia. *Journal of Applied Ichthyology*, 30(5):1096-1098.

Maruska, K. P., Cowie, E. G., & Tricas, T. C. (1996). Periodic gonadal activity and protracted mating in elasmobranch fishes. *The Journal of Experimental Zoology*, 276: 219-232.

Mollet, H. F. (2002). Distribution of the pelagic stingray, *Dasyatis violacea* (Bonaparte, 1832), off California, Central America, and worldwide. *Marine Freshwater Research*, 53: 525-530.

Moore, J. E., Cox, T. M., Lewison, R. L., Read, R. L., Bjorkland, R., McDonald, S. L., Crowder, L. B., Aruna, E., Ayissi, I., Espeut, P., Joynson-Hicks, C., Pilcher, N., Poonian, C.N.S., Solarin, B., & Kiszka, J. (2010). An interview-based approach to assess marine mammal and sea turtle capture in artisanal fisheries. *Biological Conservation*, 143:795-805.

Motta, P. J. (2004). Prey capture behaviour and feeding mechanics of elasmobranchs. In: J. C. Carrier, J. A. Musick, and M. R. Heithaus (Eds.), Biology of sharks and their relatives. (pp: 165-202). Boca Raton: CRC Press.

Myers, P., R. Espinosa, C. S. Parr, T. Jones, G. S. Hammond, and T. A. Dewey. (2021). The animal diversity web (online). Accessed at https://animaldiversity.org.

Nair, R. J., & Zacharia, P. U. (2015). Introduction to the classification of elasmobranchs. Kochi: Central Marine Fisheries Research Institute.

Neer, J. A. (2008). The biology and ecology of the pelagic stingray, *Pteroplatytrygon violacea* (Bonaparte, 1832). In M. Camhi and E. Pikitch (Eds), Sharks of the open ocean. (pp 152-159). New York: Blackwell Scientific.

Oliver, S., Braccini, M., Newman, S. J., & Harvey, E. S. (2015). Global patterns in the bycatch of sharks and rays. *Marine Policy*, 54:86-97.

O'Shea, O.R. (2012). The ecology and biology of stingrays (Dasyatidae) at Ningaloo Reef, Western Australia. Australian Institute of Marine Science.

Piovano, S., Clo, S., & Giacoma, C. (2010). Reducing longline bycatch: The larger the hook, the fewer the stingrays. *Biological Conservation*, 143:261-264.

Rueda, L. 2008. Bycatch of sea turtles in Spain. 10.13140/RG.2.1.1414.7280. Retrieved from

Shao, K. T., Ho, H. C, Lin, P. L, Lee, P. F., Lee, M. Y., Tsai, C. Y., Liao, Y. C., & Lin, Y. C. (2008). A checklist of the fishes of Southern Taiwan, Northern South China Sea. *The Raffles Bulletin of Zoology*, 19 (Supplement):233-271.

The elasmodiver shark and ray field guide. Retrieved February 23, 2021

Shester, G. G., & Micheli, F. (2011). Conservation challenges for small-scale fisheries: Bycatch and habitat impacts of traps and gillnets. *Biological Conservation*, 144:1673-1681.

Straube, N., White, W. T., Ho, H. C., Rochel, E., Corrigan, S., Li, C., & Naylor, G. J. P. (2013). A DNA sequence-based identification checklist for Taiwanese chondrichthyans. *Zootaxa*, 3752(1): 256-278.

Sulikowski, J. A., Tsang, P. C. W., & Howell, W. H. (2004). An annual cycle of steroid hormone concentrations and gonad development in the winter skate, *Leucoraja ocellata*, from the western Gulf of Maine. *Marine Biology*, 144: 845-853.

Thorburn, D. C., Morgan D. L., Rowland, A. J., & Gill, H. (2004). Elasmobranchs in the Fitzroy River, Western Australia. Centre for Fish and Fisheries Research.

Try, I., Jensen, K. R., Sereywath, P., & Longdy, V. (2004). Shark and ray fisheries in Cambodia: A review of national management activities. *Fish for The People*, 2(1):24-31.

Vaudo, J. (2011). Habitat use and foraging ecology of a batoid community in shark bay, Western Australia. FIU Electronic Theses and Dissertations. Paper 367.

Veras, D. P., Junior, T. V., Hazin, F. H. V., Lessa, R. P., Travassos, P.E., Tolotti, M.T., & Barbosa, T.M. (2009). Stomach contents of the pelagic stingray (*Pteroplatytrygon violacea*) (Elasmobranchii: Dasyatidae) from the tropical Atlantic. *Brazilian Journal of Oceanography*, 57(4):339-343.

Vidthayanon, C. (1999). Species composition and diversity of fishes in the South China Sea, The area I: The gulf of Thailand and east coast of Peninsular Malaysia. In: Proceedings of the First Technical Seminar on Marine Fishery Resources Survey in the South China Sea, Area I: Gulf of Thailand and Peninsular Malaysia, 24-26 November 1997, Bangkok, Thailand. Samut Prakan, Thailand, Training Department, Southeast Asian Fisheries Development Center, pp. 172-240.

Wallman, L. H., & Bennett, W A. (2006). Effects of parturition and feeding on thermal preference of Atlantic stingray, *Dasyatis sabina* (Lesueur). *Environmental Biology of Fishes*. 75: 259-267.

Weidner, T. A. (2014). Combined gut content-stable isotope trophic analysis and satellite tagging of the pelagic stingray *Pteroplaytrygon violacea* (Bonaparte, 1832) from the Western North Atlantic Ocean.

Wetherbee, B. M., & Cortés, E. (2004). Food consumption and feeding habits. In: J. C. Carrier, J. A. Musick, and M. R. Heithaus (Eds.), Biology of sharks and their relatives. (pp. 223-243). CRC Press, Boca Raton.

White, W. T., Giles, J., Dharmadi., & Potter, I. C. (2006). Data on the bycatch fishery and reproductive biology of mobulid rays (Myliobatiformes) in Indonesia. *Fisheries Research*, 82:65-73.

White W. T ., & Dharmadi. (2007). Species and size compositions and reproductive biology of rays (Chondrichthyes, Batoidea) caught in target and non-target fisheries in eastern Indonesia. *Journal of Fish Biology*. 70:1809-1837.

Windusari, Y., & Iqbal, M. (2018). A Review of Recent Status on Stingrays (Chondrichthyes: Dasyatidae) In Indonesian Waters. *Oceanography & Fisheries Open access Journal*, 6(3):1-4.