Catch abundance and fishing season from vulnerable and endangered Elasmobranch species in Tanjung Luar Fishery

B M Simeon1*, Fahmi2, M Ichsan1, E Muttaqin1, S Oktaviyani2, U Mardhiah1, and I Yulianto1,3

1Wildlife Conservation Society-Indonesia Program, Bogor, Indonesia
2Indonesian Science Institute
3Faculty of Fisheries and Marine Sciences, Bogor Agricultural University

*E-mail: bsimeon@wcs.org

Abstract. The elevated extinction risk of elasmobranchs is proportional with the increase of fishing mortality due to overfishing. Indonesia is the biggest shark fishing country in the world, with Tanjung Luar as a fishing village specifically targeting sharks. More than 30 species of sharks and rays that have been landed in Tanjung Luar recently received increased conservation status under the International Union for Conservation of Nature (IUCN). This research aimed to analyze the catch abundance of vulnerable or endangered elasmobranchs in Tanjung Luar and identify the fishing seasons. Four years of landing monitoring data from 2014-2017 were analyzed the fishing seasons and fisheries pattern of vulnerable or endangered elasmobranchs species in Tanjung Luar, calculated Catch per Unit Effort (CPUE) based on fishing power index and also fishing season index. The CPUE of sharks and rays from 2014 to 2017 fluctuated but was not significantly different. We found that shark fishing season occurred in six months and ray fishing season occurred only in four months. The results suggested that management measures should focus on gear control and spatio-temporal closures which could have significant benefits for the conservation of elasmobranch species, and may help to improve the overall sustainability of the fishery.

Keywords: elasmobranch, vulnerable, endangered, Tanjung Luar, CPUE, fishing season

1. Introduction

Predominant shark species are predators that play an important role within the food webs. Reductions in the populations of large sharks can initiate trophic cascades through top-down effects [1-3]. Besides from sharks, rays also have an important role for the ecosystem [4]. Some pelagic rays are known as meso predators and top predators. Meanwhile, smaller species are not considered to be apex predators [2]. Yet, there is some evidence that many benthic and demersal species can have important functional roles in marine systems [4].

It is well known that the elevated extinction risk of elasmobranchs is proportional with the increase of fishing mortality due to overfishing [5]. Elasmobranchs naturally are more affected by intense fishing activity than teleosts [1]. It is partly due to its biological characteristics such as life history and their position in trophic food webs [3, 4]. In recent decades, widespread exploitation and habitat degradation have resulted in substantial declines in shark populations resulting in a quarter of their species being threatened with extinction based on conservation status by the International Union for Conservation of Nature (IUCN) [1, 3, 5, 6].
Indonesia is known as the biggest sharks fishing nation in the world, and Tanjung Luar is known as a shark fishery hotspot in Indonesia [7, 8]. Tanjung Luar is located in Eastern Lombok, a fishing port conterminous with the Indian Ocean. Sharks and rays are targeted legally and considered profitable for local people. More than 30,000 sharks and rays have been landed in Tanjung Luar since 2014, with more than 25 species of total catch listed as vulnerable and endangered species by IUCN [9]. However, conservation status without management will be insufficient to reduce overexploitation. Considering its importance to local people, fisheries management is urgently needed to protect sharks and make its fishing more sustainable.

Catch per unit effort (CPUE) is an approach that can be used to evaluate basic information to assess trend of catch abundance [10, 11]. Furthermore, sharks and rays which were landed in Tanjung Luar were caught by different fishing gears [9, 12]. This means that sharks and rays were caught by different efforts due to particular characteristics of the different fishing gears. On the other hand, considering that fish abundance in Indonesia is influenced by season, it is also important to assess sharks and rays fishing season to identify its fishing pattern [13]. Fishing season index is usually used to increase fishing effectivity [14]. In this case, we want to use fishing season index to provide recommendations on how to manage efforts to conserve the endangered and vulnerable species of sharks and rays.

Shark and ray fishery is one of important commodities for fisheries community in Tanjung Luar [15]. In order to develop sharks and rays management in Tanjung Luar, some baseline research should be done. This research aimed to analyze the temporal catch abundance of vulnerable and endangered elasmobranch in Tanjung Luar and to identify its fishing season.

2. Methods

2.1. Data collection
This research was conducted in Tanjung Luar Fishing Port (figure 1). Fishers from Tanjung Luar usually fishing from Southern Bali and Lombok down to Northern Australia, Flores Sea, Makassar Strait. Two well-trained enumerators identified species and collected data in the port with monthly supervision to maintain the data quality. Elasmobranch landings were recorded from the Tanjung Luar shark auction facility every morning, from 05.00-10.00 AM from 1 January 2014 to 31 December 2017. We recorded catch data such as month, year, species, fishing gear, fishing ground, and trip ID. Shark and ray fishery in Tanjung Luar is commonly conducted using two targeted fishing gears: set bottom longline and drift longline, although sharks and rays can also be caught by gillnet as by-catch product. We divided the elasmobranch fishing ground into four clusters, which were: fishing ground I for the southern waters of Bali, Lombok, and Sumbawa Island; fishing ground II for the southern waters of Sumba, Flores, and Savu Sea; fishing ground III for the Flores Sea and Makassar Strait; and fishing ground IV for the Java Sea near Kalimantan and Madura.

2.2. Data analysis
We analyzed catch per unit effort (CPUE) by using fishing power index per fishing gear [16,17]. The estimation of CPUE was done temporally (based on the month of sampling campaign). Afterwards, the standardized CPUE was used for fishing seasonal pattern analysis [18].
3. Results and Discussion

During the four years, we recorded 16,098 individuals of vulnerable and endangered sharks and rays species landed. It consisted of 15 species of sharks (13 vulnerable and two endangered), and 11 rays (11 vulnerable) (table 1). The largest number of sharks species which were caught were silky shark (*Carcharhinus falciformis*) and scalloped hammerhead shark (*Sphyrna lewini*), with vulnerable and endangered status respectively. The largest number of rays species were bottlenose wedgefish (*Rhynchobatus australiae*) and Jenkins whipray (*Pateobatis jenkinsii*) (table 1).

Sharks and rays were caught as target by drift longline and set bottom longline, and as by-catch by gillnet. Standardization of fishing power index showed that fishing effort for sharks had drift longline as the reference standard fishing gear. Rays showed different result in which set bottom longline was considered as their reference standard fishing gear.

From 2014 to 2017, catch abundance of sharks increased from five to eight (SE) individuals per trip. The annual trend of sharks was not significantly different. However, the catch abundance of rays changes significantly, increasing from 2014 to 2017 and decreasing significantly in 2017 (figure 2).

We found that the fishing pattern season of sharks and rays was not similar. Sharks fishing season occurred in February, March, July, August, September, and October. In general, shark fishing season started in February until March, then decreased until June. The fishing season started again in July until October. Ray fishing season occurred in February, March, and June (figure 3).

Endangered and vulnerable sharks were mostly caught in cluster 4 in 2014 and 2015. Even in 2016, catch abundance in cluster 3 and 4 was not significantly different. In 2017, endangered and vulnerable sharks were mostly caught in cluster 2. There were some patterns concerning fishing season and fishing ground. Fishing ground which had high fishing season in March were the southern waters of Sumba and Savu Sea. April and May were generally low fishing season, but the fishing season in Southern Nusa Tenggara, Northern Nusa Tenggara, Flores Sea, until Makassar Strait were better (figure 5).

Meanwhile, rays fishing season occurred in January, February, March, and June (figure 3). Mostly endangered and vulnerable rays were caught in cluster 3, even in 2016 the catch abundance in cluster 4 increased significantly (figure 4). We found that in August and December, the fishing season occurred in cluster 1 and 3 (figure 5).
Table 1. Vulnerable and endangered elasmobranchs landed in Tanjung Luar from 2014-2017.

| Category | Species            | Common name              | IUCN status | Catch (individual) |
|----------|--------------------|--------------------------|-------------|--------------------|
| Ray      | Himantura uarnak   | Reticulate whipray       | Vulnerable  | 40                 |
| Ray      | Maculabatis gerrardi | Whitespotted whipray    | Vulnerable  | 16                 |
| Ray      | Mobula alfredi     | Reef manta ray           | Vulnerable  | 1                  |
| Ray      | Mobula birostris   | Giant manta ray          | Vulnerable  | 7                  |
| Ray      | Mobula tarapacana  | Sicklefin devil ray      | Vulnerable  | 18                 |
| Ray      | Pateobatis fai     | Pink whipray             | Vulnerable  | 27                 |
| Ray      | Pateobatis jenkinsii | Jenkins whipray        | Vulnerable  | 146                |
| Ray      | Rhina ancylostoma  | Shark Ray                | Vulnerable  | 32                 |
| Ray      | Rhynchobatus australiae | Bottlenose wedgefish   | Vulnerable  | 557                |
| Ray      | Taeniourus meyeni  | Blotched fantai ray      | Vulnerable  | 81                 |
| Ray      | Urogymus granulatus | Mangrove whipray        | Vulnerable  | 5                  |
| Shark    | Alopias pelagicus  | Pelagic thresher shark   | Vulnerable  | 388                |
| Shark    | Alopias superciliosus | Bigeye thresher shark  | Vulnerable  | 150                |
| Shark    | Carcharhinus albimarginatus | Silvertip shark     | Vulnerable  | 331                |
| Shark    | Carcharhinus falciformis | Silky shark           | Vulnerable  | 9910               |
| Shark    | Carcharhinus longimanus | Oceanic whitetip shark | Vulnerable  | 12                 |
| Shark    | Carcharhinus obscurus | Dusky shark            | Vulnerable  | 761                |
| Shark    | Carcharhinus plumbeus | Sandbar shark          | Vulnerable  | 146                |
| Shark    | Hemigaleus microstoma | Sicklefin weasel shark | Vulnerable  | 1                  |
| Shark    | Hemipristis elongata | Snaggletooth shark    | Vulnerable  | 36                 |
| Shark    | Isurus oxyrinchus  | Shortfin mako shark     | Vulnerable  | 618                |
| Shark    | Isurus paucus      | Longfin mako shark      | Vulnerable  | 134                |
| Shark    | Nebrius ferrugineus | Tawny nurse shark       | Vulnerable  | 41                 |
| Shark    | Sphyra levini      | Scalloped hammerhead shark | Endagered  | 2425               |
| Shark    | Sphyra mokarran    | Great hammerhead shark  | Endagered   | 183                |
| Shark    | Stegostoma fasciatum | Zebra shark            | Vulnerable  | 32                 |

The catch abundance of vulnerable and endangered sharks which were caught and landed did not significantly increase from 2014 to 2017. This condition could occur because each fleet from Tanjung Luar fishers was already at its maximum effort, or because of a constant number of shark population. It is very interesting that the catch abundance was stable while the number of fleet decreased from year to year [9,15]. It was known that the number of shark fishing fleets from another fishing base that had the same fishing ground had also decreased in the last decade [19], which means less competition between shark fishers within the same fishing ground. Even when the number of fleet decreased, total trip by drift longline as reference fishing gear did not decrease at all. This shows that the remaining fleet conducted more trips in order to maximize the effort.

Similar research showed different result. Catch abundance for silky sharks increased from 2015 to 2016 [13]. However, catch abundance showed the result for 15 species which was dominated by silky shark. Another possible cause could be the decrease of catch from other species while the catch abundance of silky sharks increased.
Figure 2. Catch per Unit Effort (number of individual per trip) for vulnerable and endangered sharks and rays in Tanjung Luar Fishing Port.

Figure 3. Vulnerable and endangered sharks and rays fishing season in Tanjung Luar Fishing Port, 
- IMP rays, IMP shark.
Figure 4. Catch per Unit Effort (number of individual per trip) for vulnerable and endangered sharks and rays in Tanjung Luar Fishing Port, (a) = sharks, (b) = rays, = I : Southern waters of Bali, Lombok, and Sumbawa Island, = II : Southern waters of Sumba, Flores, and Save Sea, = III : Flores Sea and Makassar Strait, = IV : Java Sea near Borneo and Madura.

Figure 5. Vulnerable and endangered shark and ray fishing season in different fishing ground of Tanjung Luar fishers, (a) = sharks, (b) = rays, = I : Southern waters of Bali, Lombok, and Sumbawa Island, = II : Southern waters of Sumba, Flores, and Save Sea, = III : Flores Sea and Makassar Strait.

On the other side, the catch abundance of vulnerable and endangered rays decreased from 2014 to 2017 in conjunction with its trip. Total trip of set bottom longline decreased from 2014 to 2017. Based on interview result, this pattern might be due to two targeted species of manta ray (Mobula birostris and mobula alfredi) entering the fully protected status in 2014 [20]. As a precautionary effort, fishers might have minimized the fishing of all mobulid species.

Index fishing season of vulnerable and endangered sharks in each fishing ground showed that the fishing season also depended on its fishing grounds. From the four clusters of fishing grounds, only three fishing grounds could be analyzed as index fishing season: cluster I, cluster II, and cluster III. This shows that the number of vulnerable and endangered sharks caught in cluster 4 was not as many as the three other clusters. However, in 2014-2016 the CPUE in cluster IV was higher than the other three clusters. That condition occurred due to the high number of catch only in particular months. The other three clusters showed different fishing seasons from one another. Cluster I showed high fishing season in January and May. Cluster II showed high fishing season in March, June, August, September, October, and November. Cluster III showed high fishing season in April, August, and September.

Generally, vulnerable and endangered shark fishing season started in March until June. The fishing season started again in July until November. The number of vulnerable and endangered sharks increased in several fishing grounds, but decreased in other fishing grounds. There were some possibilities that
some species had migratory behavior, for example the migratory behavior of silky sharks [13]. Similar fishing season pattern was also shown in other research, which show the period between June and October, which generally corresponds to the southeast monsoon season when there is a strong upwelling along the Indian Ocean coastlines of Sumatra, Java, Bali and Nusa Tenggara, leading to high levels of primary productivity and subsequently to elevated fish catches [8, 21, 22].

Rays fishing season can generally be found in January, February, March, and June. However, there was no specific fishing grounds, as proven by the scattered fishing areas. From the four cluster of fishing ground, only two clusters of fishing ground could be analyzed as index fishing season: cluster I and cluster II. This shows that the numbers of vulnerable and endangered sharks caught in cluster III and IV were not as many as the three other clusters. That condition could occur due to the high number of catch occurring only in particular months and particular places. The distance between fishing ground and fishing base of cluster I and II was not as far as cluster III and IV. This condition also explained the characteristic of set bottom longline as reference fishing gear. Set bottom longlines conduct the fishing trip closer comparing with drift longline. Rays which are commonly caught by set bottom longline are commonly found at coastal inshore, benthic on sandy bottoms, or shelter in caves and under ledges on reef [23]. We can assume that the fishing ground and fishing season pattern of vulnerable and endangered rays are more scattered compared to sharks. However, the character of fishing ground is definite in coastal area and the bottom waters.

Acknowledgements

We wish to acknowledge the support provided by fishers and enumerators in Tanjung Luar for their great cooperation during the fieldwork. We also thank the donor, the Darwin Initiative and Sharks Conservation Fund, for four years of landing monitoring. We thank the provincial local government and Ministry of Marine Affairs and Fisheries. We thank Siska Agustina who helped us with the analysis method.

References

[1] Stevens J D, Bonfil R, Dulvy N K and Walker P A 2000 The effects of fishing on sharks, rays, and chimaeras (chondrichthians), and the impucation for marine ecosystem ICES J. Mar. Sci. 57 476-494
[2] Myers R A, Baum J K, Shepherd T D, Powers S P and Peterson S H 2007 Cascading effects of the loss of apex predatory sharks from coastal ocean Sci. 315 (5820) 1846-1850
[3] Ferretti F, Worm B, Britten G L, Heithaus M R and Lotze H 2010 Patterns and ecosystem consequences of shark declines in the ocean Ecol. Letter 13 1055-1071
[4] Field F, Meekan M G, Buckworth R C and Bradshaw C J A 2009 Susceptibility of sharks, rays, and chimaeras to global extinction Mar. Biol. 56 (09) 275-363
[5] Simpfendorfer C A and Dudley S F J 2006 Population status of 14 shark species caught in the protective gillnets of KwaZulu-Natal beaches, South Africa, 1978-2003 Mar. Freshwater Res. 57 (2) 225-240
[6] Dulvy N K, Fowler S F, Musick J A, Cavamagh R D, Kyne P M, Harrison L R and White WT 2014 Extinction risk and conservation of the world’s sharks and rays ELife (3) 1-34
[7] Dent F and Clarke S 2015 State of the global market for shark products (FAO Fisheries and Aquaculture Technical Paper)
[8] Fahmi and Dharmadi 2015 Pelagic shark fisheries of Indonesia’s Eastern Indian Ocean Fisheries Management Region African J. Mar. Sci. 37 (2) 259-265
[9] Simeon B M, Agustina S, Muttaqin E, Yulianto I and Ichsan M 2017 Wildlife Conservation Society : Technical Report Sharks and Rays Fisheries in West Nusa Tenggara (Bogor, Indonesia)
[10] Harley S J, Myers R A and Alistair D A 2001 Is catch-per-unit-effort proportional to abundance? CJFAS 58 (9) 1760-1722
[11] Mahévas S, Sandon Y and Biseau A 2004 Quantification of annual variations in fishing power due to vessel characteristics: an application to the bottom-trawlers of South Brittany target in
anglerfish (*Lophius budegassa* and *Lophius piscatorius*) *Journal of Marine Science* **61** 71-83

[12] Sentosa A A and Dharmadi 2017 Catch and relative abundance of some sharks landing in Tanjung Luar, Lombok *Widyariset* **3** (2) 131-142

[13] Simeon B M, Muttaqin E, Mardhiah U, Ichsan M, Dharmadi, Prasetyo A and Yulianto I 2018 Increasing Abundance of Silky Sharks in the Eastern Indian Ocean: Good News or a Reason to be Cautious? *Fishes* **3** (3) 29

[14] Sarwanto C, Wiyono E S, Nurani T W and Haluan J 2014 The Dynamics of fishing ground and catches diversity of small-scale fisheries in Southern Java Waters, Indonesia *IJSBAR* **15** 325-335

[15] Lestari P W, Sayuti M N, Muhsin, Akbar B A, Sundari E, Iasnaini and Rahmayanti S 2017 Kajian Sosial Ekonomi Nelayan Hiu Tanjung Luar, Lombok Timur, Nusa Tenggara Barat Technical Report Wildlife Conservation Society – Indonesia Program

[16] Gulland J A 1969 Manual of methods for fish stock assessment Part 1, Fish population analysis FAO Manual Fisheries Science

[17] Spare P, Venema SC Introduction to tropical fish stock assessment, Part 1 Manual FAO Fisheries Technical Paper No.306.1 Rev 2 FAO

[18] Ulrich C and Solgaard A B 2004 Dynamics of fisheries, and the flexibility of vessel activity in Denmark between 1989 and 2001 *ICES Journal of Marine Science* **61** 308-322

[19] Simeon B M 2016 Condition and Impact of Silky Shark Fisheries in the Ecosystem [Thesis] (Bogor: Bogor Agricultural University)

[20] Indonesia Ministry of Marine Affairs and Fisheries (MMAF) 2014 Fully protection status of manta ray Minister degree 2014 (4)

[21] Susanto R D, Gordon A L and Zhen Q 2001 Upwelling along the coast of Java and Sumatera *Geophysical Res. Letter* **28** (8) 1599-1602

[22] Gaol J L, Leben R R, Vignudelli S, Mahapatra K and Okada Y Variability of satellite-derived sea surface height anomaly, and its relationship with Bigeye tuna (*Thunnus obesus*) catch in the Eastern Indian Ocean *European J. Remote Sensing* **48** (1) 465-477

[23] Last P R, White W T, de Carvalho M R, Sertr B, Stehmann M F W and Naylor G J P 2016 Rays of the World. CSIRO Publishing