Analysis of spot-tailed shark and Indo-Pacific sailfish landed at Palabuhanratu fishing port as longline bycatch in the Eastern Indian Ocean

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Abstract. The Palabuhanratu fishing port has high activity at West Java south coast. One of the fishing gears used in Palabuhanratu is the longline. In addition to tuna (*Thunnus* spp.) as a primary target of longline, Indo-Pacific sailfish (*Istiophorus platypterus*) and spot-tailed shark (*Carcharhinus sorrah*) are bycatches of longline fishing. Spot-tailed sharks have a high economy value because of their fins. Demand of shark fins, fresh or frozen, have been increasing yearly. The increasing need for fish protein in Indonesia demands a high production of fish catch as well. This causes the catches of spot-tailed shark and Indo-Pacific sailfish to be utilized continuously and this can threaten the sustainability of the fishery resources. The management of spot-tailed shark and Indo-Pacific sailfish that have been done so far tend to encourage the excessive use of natural resources. The objectives of this study are as follows: to analyze the condition of production of spot-tailed shark and Indo-Pacific sailfish during 2015-2019; to analyze the productivity of effective and efficient spot-tailed shark and Indo-Pacific sailfish fisheries at Palabuhanratu fishing port, Sukabumi, West Java; to analyze the seasonal pattern of spot-tailed shark and Indo-Pacific sailfish fisheries in Palabuhanratu fishing port. The methods used are catch composition analysis, productivity analysis and seasonal fishing pattern. The results show that Indo-Pacific sailfish and spot-tailed shark fisheries had fluctuations every year from 2015 to 2019, tending to decline because of the overexploitation causing the stock to dwindle. Another cause is the size of the fishing effort carried out. The fishing season for spot-tailed shark has 2 peaks, in April-June and July-August, the catch being moderate in the rest of the year. Indo-Pacific sailfish seasonal catch patterns are more diverse, the peaks being in May-June and July-August, with a moderate catch in September-April.
Key Words: bycatch, catch composition, CPUE, seasonal fishing pattern.

Introduction. Palabuhanratu fishing port has high activity in the West Java south coast, Indonesia. Among the fish brought here, an important one is tuna (*Thunnus* spp.). Tuna is captured here using longline fishing. Tuna longline is an effective fishing tool. Longline fishing methods are fuel efficient, environmentally friendly, clean, and can be used to catch demersal and pelagic fish. A tuna longline is passive in its operation, so it does not damage the biological resources of waters. One tuna line unit consists of a float, a float line, a main line with a number of branch lines that are hooked. The number of fishing rods used in arranger and non-arranger systems is the same (Bahtiar et al 2016). The design and construction of tuna longlines is basically divided into 2 systems, namely arranger (machine) and non-arranger (manual) systems. The difference between the two is the main rope material; the non-arranger system is made of monofilament (PA) and the arranger is made of monofilament and polyester, hauler machines, main line arrangement and branch line installation (Barat & Prisantoso 2009).

Tuna is the primary target of longline fishing, but Indo-Pacific sailfish (*Istiophorus platypterus*) and spot-tailed shark (*Carcharhinus sorrah*) are bycatches. Spot-tailed sharks have high economy value because of their fins. Demand on shark fins have increased yearly (Fong & Anderson 2002). In Indonesia, the rate of fish consumed reaches 54.49 kg per capita on average in 2019 (KKP 2020). The sustainable utilization of spot-tailed shark and Indo-Pacific sailfish can happen only if it is community oriented,

involving community interests and support. Community support can be seen in determining the economic value or valuation of fisheries in Palabuhanratu, West Java. The sustainability of the business and resources of spot-tailed shark and Indo-Pacific sailfish needs to be assisted by the government, to be preserved with optimal management. The location of Palabuhanratu fishing port is directly facing the Indian Ocean, where the area of capture in the longline operation is far and outside the bay, or in the territorial waters of the Indian Ocean. Fishing in Palabuhanratu, West Java, is generally carried out throughout the year and is known for 3 fishing seasons: the season with high catch, medium catch, and low or lack of catch season. The high catch season occurs between June and September, the moderate season is in March-May, and October-November, and the season with low catches is between December and February (Handriana 2007).

However, to find out more about the condition of spot-tailed shark and Indo-Pacific sailfish in the Eastern Indian Ocean landed in Palabuhanratu fishing port, especially regarding production, productivity and seasonal patterns from 2015 to 2019, the current study was conducted. The increasing need for fish protein in Indonesia demands a high production of fish catch as well. This causes the catches of spot-tailed shark and Indo-Pacific sailfish to be continuous and can threaten the sustainability of the fishery resources. The management of spot-tailed shark and Indo-Pacific sailfish carried out so far tend to encourage the excessive use of natural resources. If the fishing activities will not be managed properly, it will greatly threaten the sustainability of these resources. The objectives of this study are: to analyze the condition of production of spot-tailed shark and Indo-Pacific sailfish during 2015-2019; to analyze the productivity of effective and efficient spot-tailed shark and Indo-Pacific sailfish fisheries at Palabuhanratu fishing port, Sukabumi, West Java; and to analyze the seasonal pattern of spot-tailed shark and Indo-Pacific sailfish fisheries in Palabuhanratu fishing port.

Material and Method

Description of the study sites. This study was conducted at Palabuhanratu fishing port, West Java, Indonesia, in January-February 2020. The specific area is located at the gulf of Palabuhanratu, which includes in The Fisheries Management Region of the Republic of Indonesia 573 (Figure 1). Geographically, Sukabumi Regency is located at 06°57'-07°25 S and 106°49'-107°00' E, while Palabuhanratu is at 06°57'-07°07 S and 106°22'-106°33 E (Pariwono 1988). The topography of the coastal area in Sukabumi Regency is rough textured. Most of its territory is undulating terrain and consists of hilly areas, watersheds and beaches. The coastal areas and bays in Sukabumi Regency are directly related to the Indian Ocean. Palabuhanratu bay is the largest bay along the southern coast of Java. With a length of coastline of approximately 115 km, it starts from Cibareno Village, located on the border between Sukabumi Regency and Banten Province and continues to Tegalbuleud, bordering Cianjur Regency. A depth of 200 m can be found in the bay, 300 m from the coastline. Farther, the seabed declines sharply to a depth of more than 600 m in the central part of the bay (Pariwono 1988).

Method. 2 methods of analysis were used: productivity analysis and fishing seasonal patterns analysis. Productivity is a measure that shows how productive a fishing gear is in getting catches that are measured at a particular time and unit of effort. Fishing productivity of longline vessels was analyzed using the catch per unit effort (CPUE) indicator. If the value of productivity decreases, it indicates a decrease in biomass or resources; conversely, if the value of productivity increases, it indicates that the condition of the resources is good. According to Wudji & Suwarso (2015) CPUE calculations with the following formula:

$$CPUE_i = \frac{Catch_i}{Effort_i}$$

Where: $CPUE_i$ - number of catch per unit effort-i (kg per trip); $Catch_i$ - total catch-i (kg); $Effort_i$ - number of effort-i (trip).

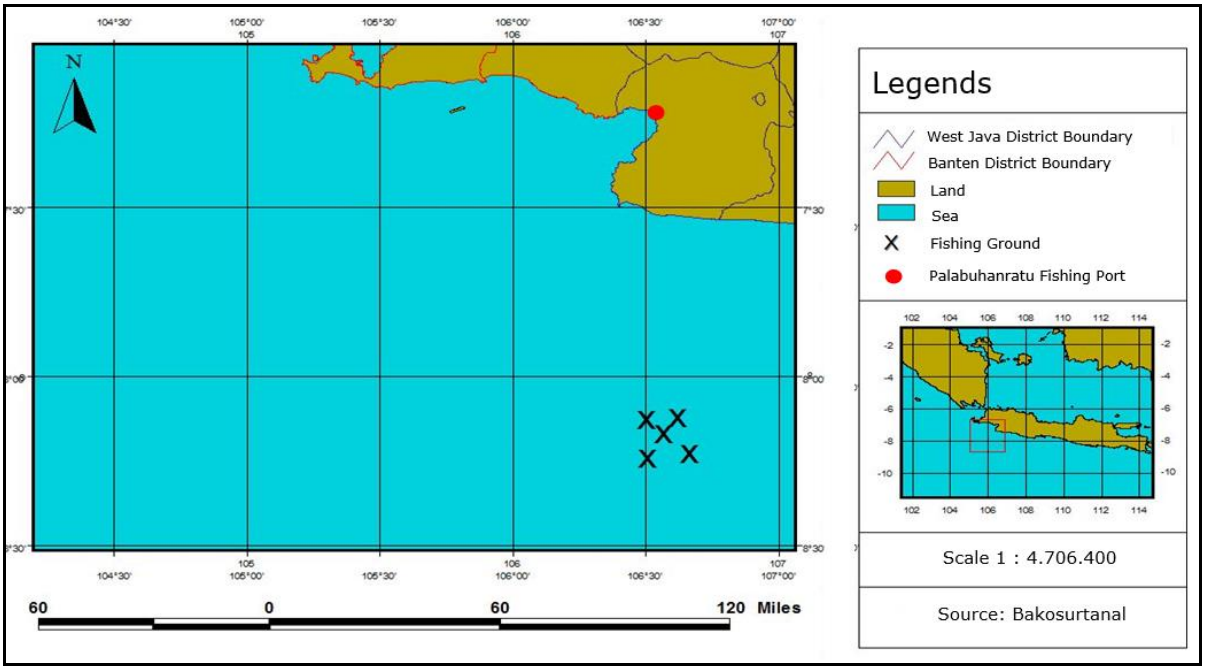

Figure 1. The study location, Gulf of Palabuhanratu, West Java, Indonesia.

Catching season patterns were analyzed using the time series analysis of the monthly catch of the longline fishing gear for five years, then proceed with calculating the moving average. The calculation steps are as follows:

1. Arrange a series of CPUEi from January 2015 until December 2019: $n_i=CPUE_i$, where i: 1, 2, 3, ..., n; n_i - CPUE sequence-i.

2. Arrange moving average CPUE for 12 months (RG)

$$RGi = \frac{1}{12}\left(\sum_{i=i-6}^{i+5} CPUE\right)$$

Where: RGi - moving average 12 month sequence-i; $CPUE_i$ - CPUE sequence-i; i: 6, 7,..., n-5.

3. Arrange moving average centered CPUE (RGP):

$$RGPi = \frac{1}{2}\left(\sum_{i=i}^{i=1} RGi\right)$$

Where: RGPi - moving average centered CPUE sequence-i; RGi - moving average 12 month sequence-i; i: 7, 8, ..., n-5.

4. Month Average Ratio (Rb):

$$Rbi = \frac{CPUEi}{RGPi}$$

Where: Rbi - month average ratio; CPUEi - CPUE sequence-i; i: 6, 7, ..., n-5.

5. Arrange average value in matrix ixj for each month, starting from June-July. Next calculate the value of the total average ratio each month, then calculate the total of whole average and catching season pattern. Average ratio for sequence month-i (RBBi):

$$RBBi = \frac{1}{n}\left(\sum_{j=1}^{n} RBij\right)$$

Where: RBBi - average ratio for sequence month-i; RBij - average ratio for sequence month in ixj matrix; i:1, 2, ..., 12; j: 1, 2, 3, ..., n. Total of month average ratio (JRRB):

$$JRRB = \sum_{i=1}^{12} RRBi$$

Where: JRRB - total month average ratio; RRBi - average of RBij for month sequence-i; i: 1, 2, ..., 12.

6. Calculate correction factor. The ideal value of JRRB is 1200, however, many factors cause the value to stray from 1200, therefore, the month average ratio must be corrected with a value, called correction factor (FK).

$$FK = \frac{1200}{JRRB}$$

Where: FK - correction factor; JRRB - total of month average ratio.

7. Catching seasonal index (IMP):

$$IMPi = RRBi \; x \; FK$$

Where: IMPi - catching seasonal index sequence-i; RRBi - average ratio for month sequence-i; i: 1, 2, ..., 12.

The catching seasonal index is used to determine the right time to carry out fishing operations, so that profits can be maximized with fish resources remaining sustainable. According to Wahju et al (2011), the fishing season was divided in 3 categories, namely peak, moderate and lean season, with the seasonal catch index (IMP) value lower than 50%, between 50 and 100% and higher than 100%, respectively.

Results and Discussion

The composition of the catch of spot-tailed shark and Indo-Pacific sailfish. Production of spot-tailed shark and Indo-Pacific sailfish fish fluctuated since 2015. This was due to the influence of the fishing season. Figure 2 shows that the highest production was in May-June, while the lowest production occurred in February-April. However, in general, the catches of Indo-Pacific sailfish are dominant compared to spot-tailed shark except in March, May, June and July. Figure 2 shows the spot-tailed shark and Indo-Pacific sailfish catch composition in 2015 (PPN Palabuhanratu 2015).

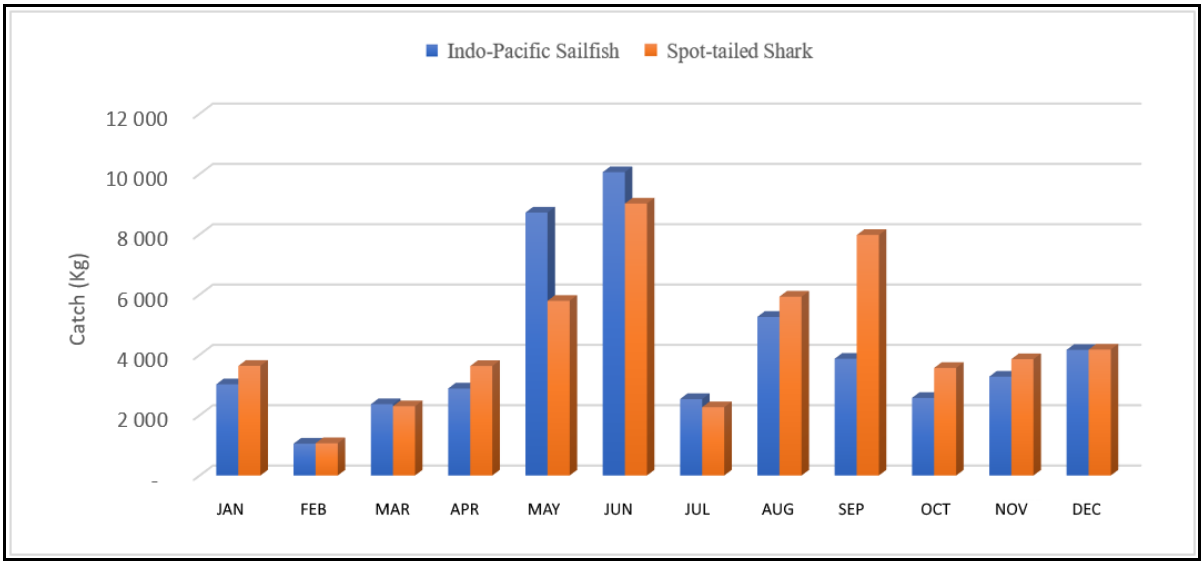

Figure 2. Catch composition of spot-tailed shark (*Carcharhinus sorrah*) and Indo-Pacific sailfish (*Istiophorus platypterus*) in 2015.

From Figure 2, it can be concluded that the highest catches of Indo-Pacific sailfish occurred in June (9071 kg) and the lowest in February (1071 kg). As for the catch of Indo-Pacific sailfish fish in 2015, the highest was in July (10058 kg) and the lowest in February (1057 kg). In Figure 3, the spot-tailed shark and Indo-Pacific sailfish catch compositions from 2016 is presented (PPN Palabuhanratu 2016).

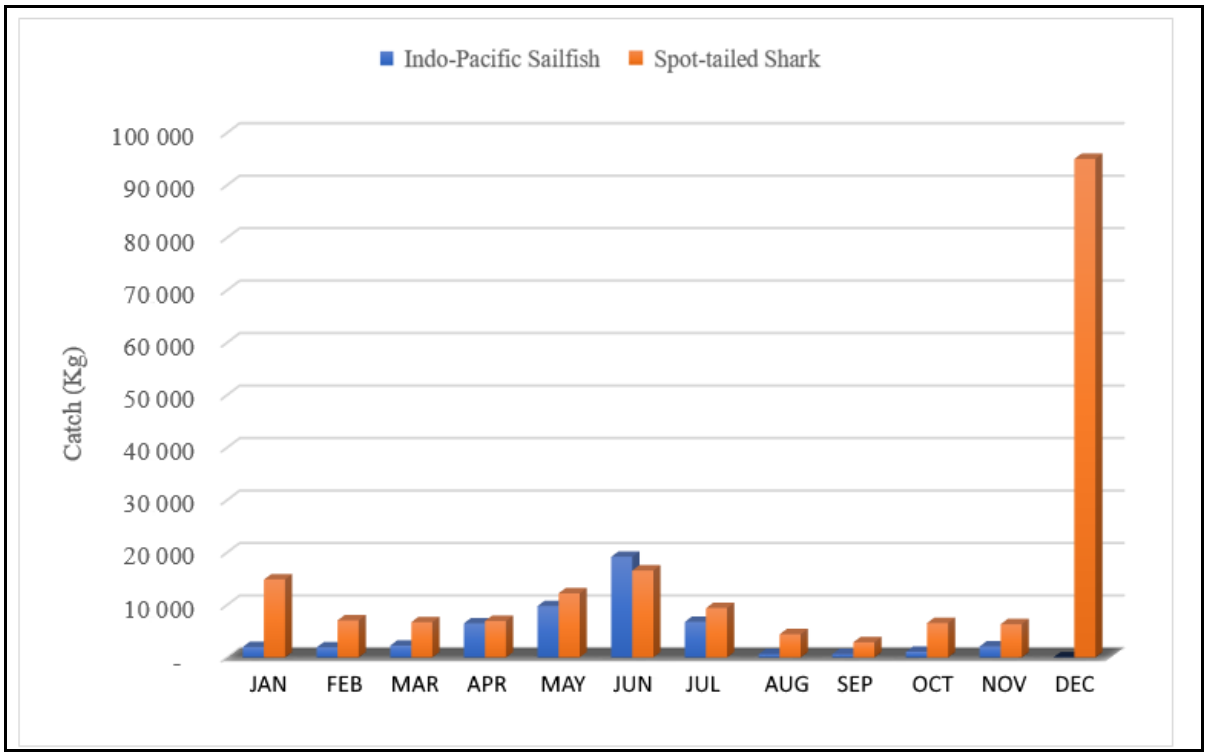

Figure 3. Catch composition of spot-tailed shark (*Carcharhinus sorrah*) and Indo-Pacific sailfish (*Istiophorus platypterus*) in 2016.

The catch composition of Indo-Pacific sailfish and spot-tailed shark fluctuated in 2016. spot-tailed shark catch experienced a very significant increase in December, with a catch of 95005 kg. A low catch was recorded in September (2888 kg). The highest sailfish

catch in 2016 occurred in June (19191 kg), and no fish were captured in December. In Figure 3, the spot-tailed shark and Indo-Pacific sailfish catch composition in 2017 is presented (PPN Palabuhanratu 2017).

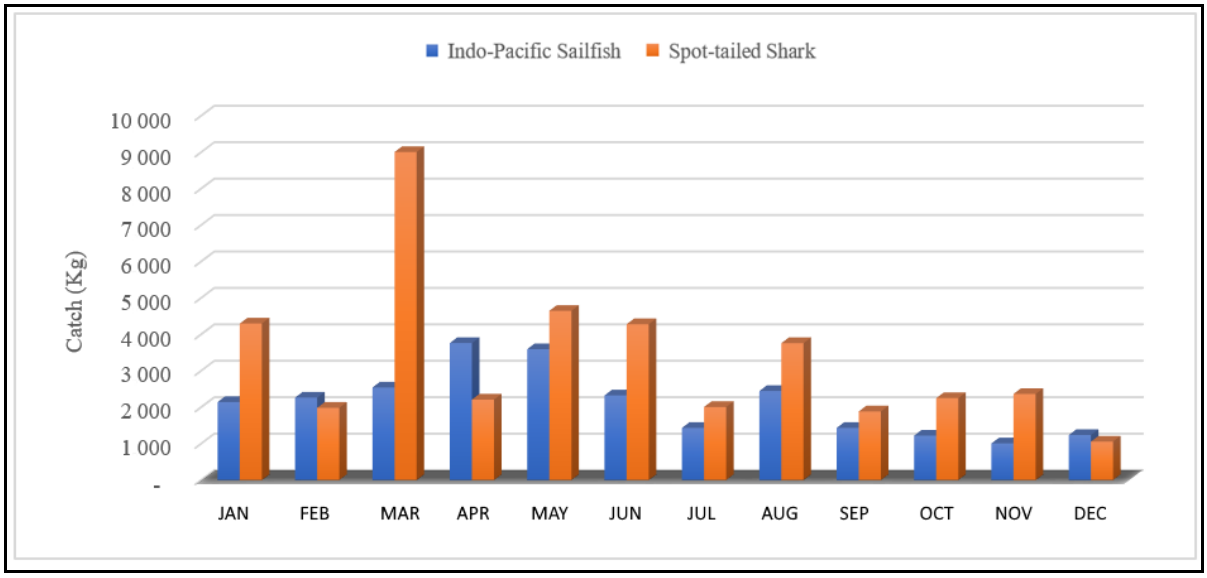

Figure 4. Catch composition of spot-tailed shark (*Carcharhinus sorrah*) and Indo-Pacific sailfish (*Istiophorus platypterus*) in 2017.

The highest catches of Indo-Pacific sailfish occurred in March (9005 kg) and the lowest in December (1057 kg). The highest level of sailfish catch was in April (3761 kg) and the lowest in November (1007 kg). In Figure 5, the spot-tailed shark and Indo-Pacific sailfish catch composition in 2018 is presented (PPN Palabuhanratu 2018).

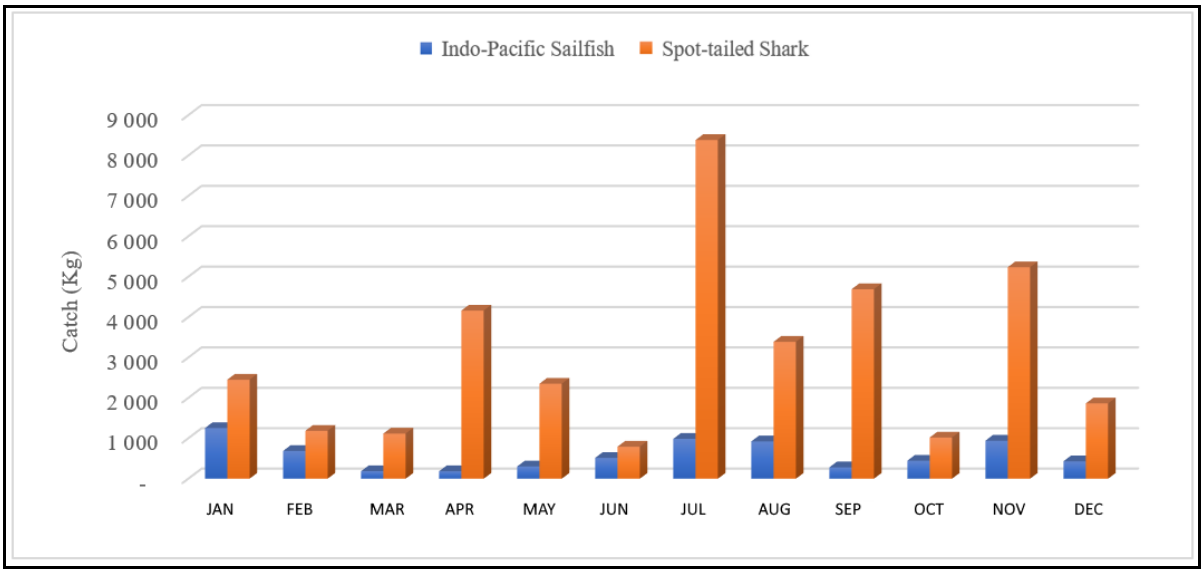

Figure 5. Catch composition of spot-tailed shark (*Carcharhinus sorrah*) and Indo-Pacific sailfish (*Istiophorus platypterus*) in 2018.

Spot-tailed shark catches were higher than sailfish catch in every month from 2018. In July, the catch of spot-tailed shark reached their peak (8384 kg), and the lowest catch was in June (792 kg). The highest catch of Indo-Pacific sailfish was in January (1254 kg) and the lowest in April (184 kg). Figure 6 presents the spot-tailed shark and Indo-Pacific sailfish catch composition in 2019 (PPN Palabuhanratu 2019).

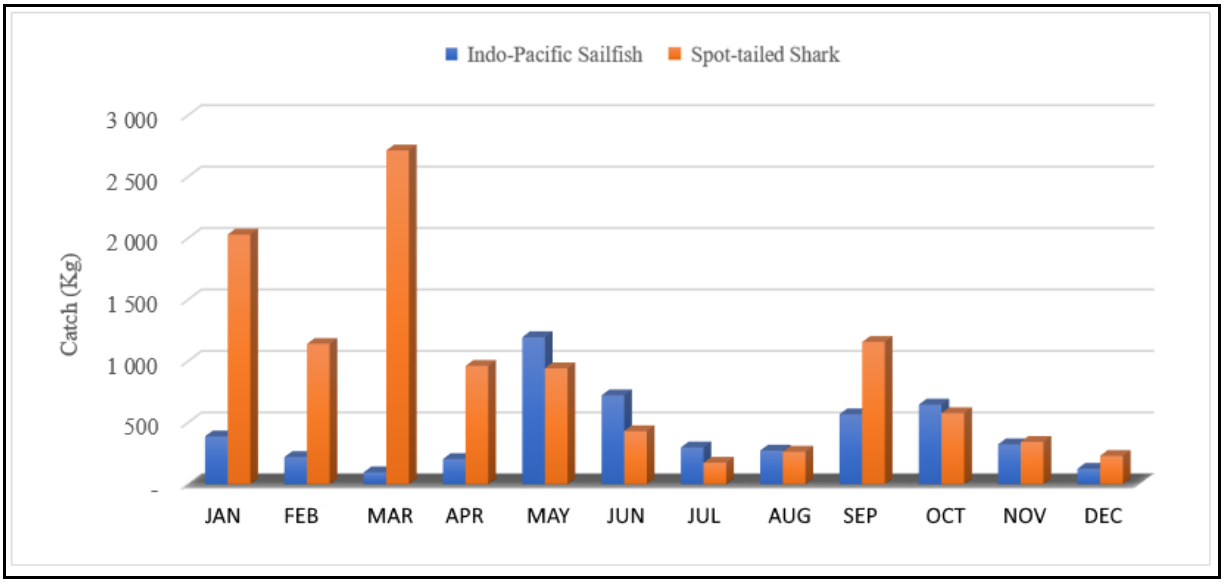

Figure 6. Catch composition of spot-tailed shark (*Carcharhinus sorrah*) and Indo-Pacific sailfish (*Istiophorus platypterus*) in 2019.

The highest Indo-Pacific sailfish catch occurred in May (1195 kg) and the lowest in March (96 kg). The highest catch of spot-tailed shark occurred in March (2714 kg) and the lowest in July (174 kg).

Figure 7 presents the overall catch composition of the 2 species from 2015 to 2019.

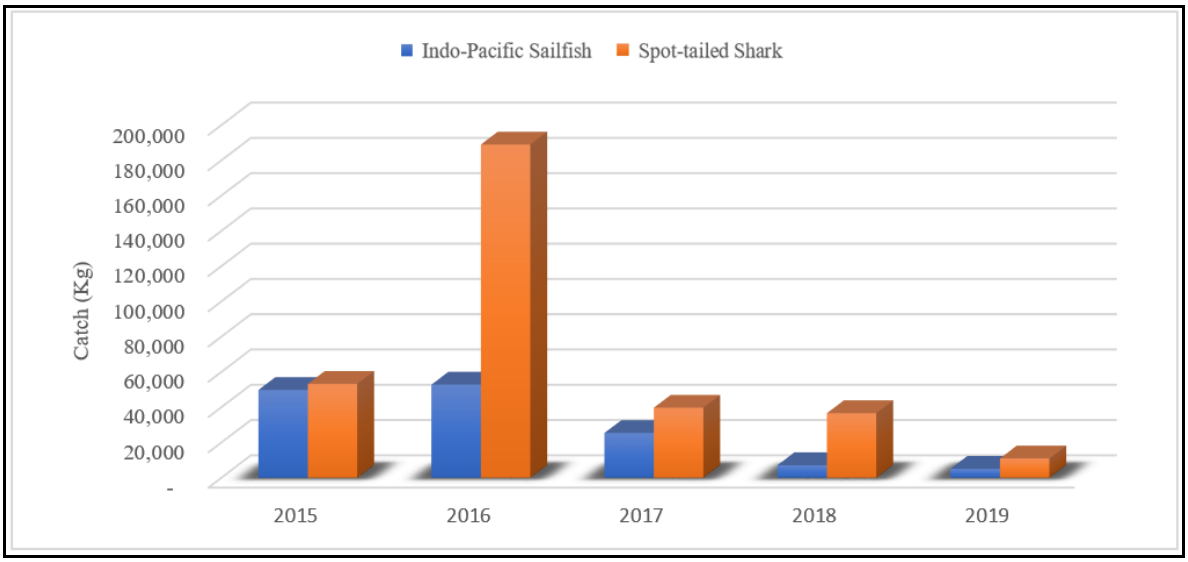

Figure 7. Catch composition of spot-tailed shark (*Carcharhinus sorrah*) and Indo-Pacific sailfish (*Istiophorus platypterus*) in 2015-2019.

In 2015, the catch of Indo-Pacific sailfish and spot-tailed shark did not differ much, both ranging between 40 and 60 tons. In 2016, there was a big difference between the catch of Indo-Pacific sailfish and spot-tailed shark. The catch of Indo-Pacific sailfish was almost the same as in the previous year. This was different from the catch of cones, which increased to almost 200 tons. In 2017 the catch decreased, and a decline occurred the following years.

Productivity analysis. The productivity of a fishing gear can vary in the fishing season. This is because during peak fishing seasons, the catches are more abundant with relatively the same units of effort. High and low CPUE values occur because during that period there were additions and reductions in both the use of fishing gear and fishing trips (effort). The highest CPUE value occurred in 2016, 354.58 kg per trip for Indo-Pacific sailfish and 1268.18 kg per trip for spot-tailed shark. The productivity of Indo-Pacific sailfish and spot-tailed shark had generally declined from 2016 to 2019. This decrease in productivity is due to overexploitation, so that the biomass of Indo-Pacific sailfish and spot-tailed shark has decreased. Figure 8 shows the CPUE from 2015 to 2019.

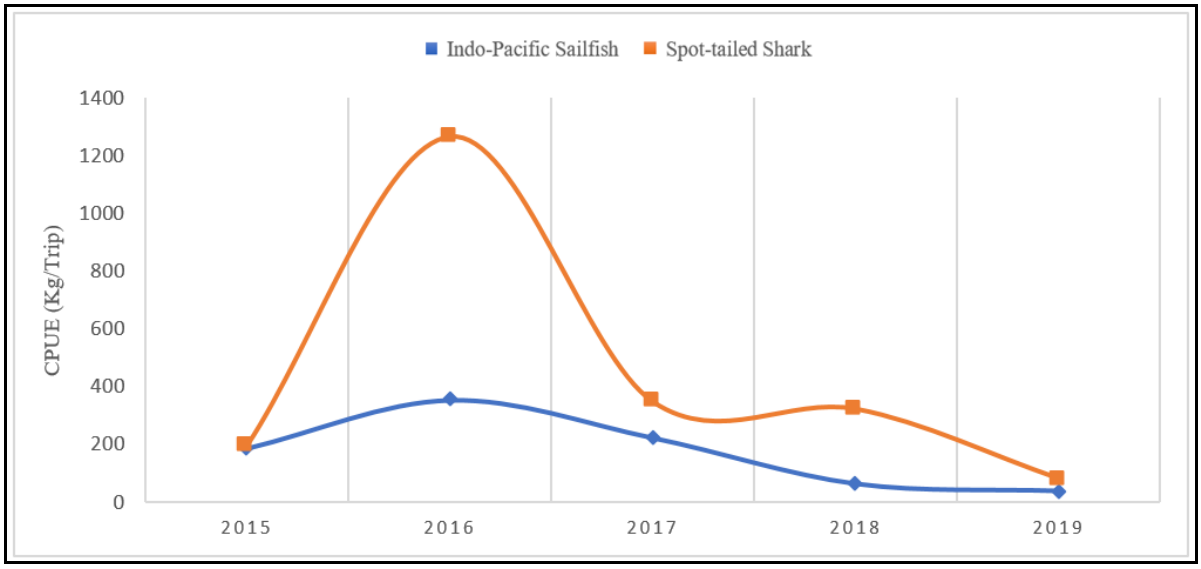

Figure 8. Catch per unit effort (CPUE) of spot-tailed shark (*Carcharhinus sorrah*) and Indo-Pacific sailfish (*Istiophorus platypterus*).

Seasonal catch pattern. The seasonal factor affects the catch of spot-tailed shark and Indo-Pacific sailfish in the waters of Palabuhanratu. Based on oceanographic conditions, usually the peak season is in the dry season where the waters are relatively calm. According to Wilopo (2005), in the dry season with the strong East Monsoon winds, there is a possibility of Ekman transport, which brings surface water away from the South Coast of Java, so there will be a vacuum (anomaly of low sea level), which results in rising water from below to the surface (upwelling). This upwelling phenomenon consistently occurs at low sea surface temperature in that period. Low sea surface temperatures cause the density at sea level to rise and moves water masses from the surface downwards (Wilopo 2005). This results in an increase in chlorophyll-a concentration, which causes a high availability of food for fish, at the primary consumer level. The availability of small fish is followed by the presence of predatory fish such as spot-tailed shark and Indo-Pacific sailfish. This causes the level of CPUE for the production of spot-tailed shark and Indo-Pacific sailfish to increase (Wilopo 2005).

The results of productivity calculations through CPUE values indicate a shift in the peak fishing periods. Shifts in peak fishing can occur as a result of uncertain seasonal changes. The spot-tailed shark seasonal catch pattern in a year is mostly moderate, with peaks in July-August, and April-June. For Indo-Pacific sailfish, the seasonal catch pattern is more diverse, with peak seasons in July-August and May-June (Figures 11 and 12).

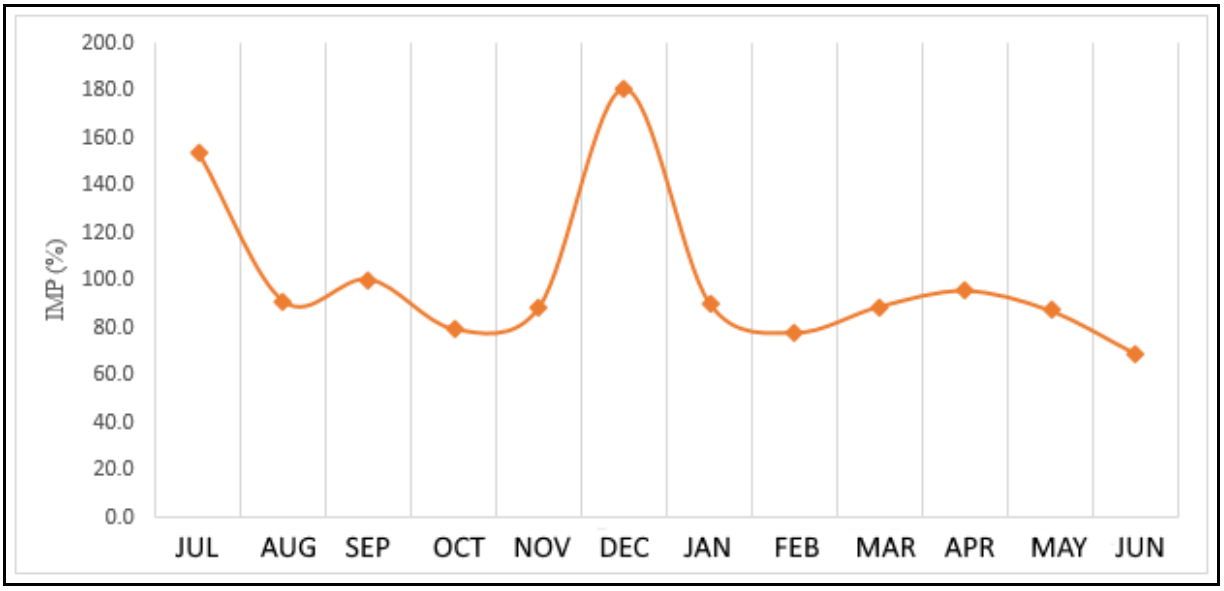

Figure 11. Catching seasonal index sequence (IMP) of spot-tailed shark (*Carcharhinus sorrah*).

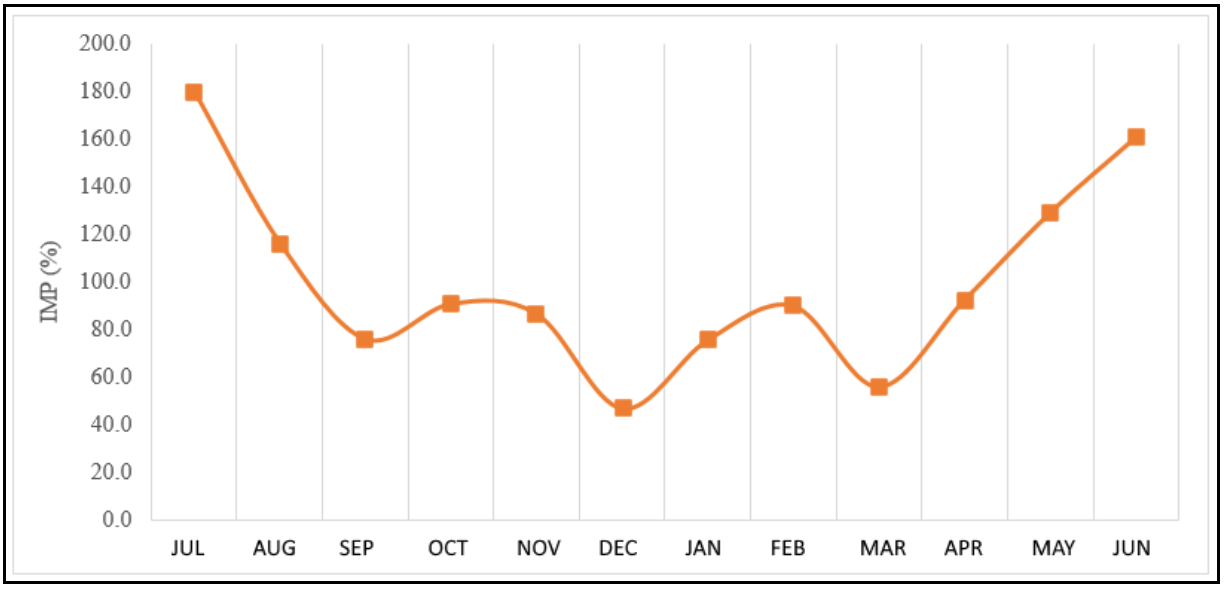

Figure 12. Catching seasonal index sequence (IMP) of Indo-Pacific sailfish (*Istiophorus platypterus*).

Fluctuations in the catches from 2015-2019 showed a natural phenomenon that occurred in PPN Palabuhanratu. Before there was a high demand for Indo-Pacific sailfish, fishermen did not target it, so its production was relatively the same as that of Indo-Pacific sailfish fish. However, in 2016, the production of Indo-Pacific sailfish drastically increased and reached five times that of Indo-Pacific sailfish fish production. The demand from various parties caused fishermen to target the fish, so that more fishing effort are made. The same phenomenon was observed by Prihatiningsih et al (2018), where the CPUE value of spot-tailed shark fisheries in Cilacap PPS reached its peak in 2016, with a productivity reaching 4.22 tons per trip. The same was observed in other areas by Blaber et al (2009), White et al (2012), and Dharmadi et al (2013), spot-tailed sharks being the main catch target at the Fish Landing Base of Tanjung Luar, West Nusa Tenggara Province, with high production.

According to Dharmadi et al (2008), in PPN Palabuhanratu and PPS Cilacap the highest production is obtained in July and August, related to the transition from the dry season to the rainy season. The transition of the season causes the movement of monsoons from Australia to Indonesia, it is stable and causes changes in the temperature and fertility of the water, inviting spot-tailed shark to find food in shallower waters (Dharmadi et al 2008). In addition, the upwelling phenomenon that occurs in the Indian Ocean between May and September affects the fertility of the waters, so that the number of spot-tailed sharks increases (Dharmadi et al 2008). Spot-tailed shark and Indo-Pacific sailfish productions in Palabuhanratu experience fluctuations monthly. Throughout the study period, it was generally concluded that there were 4 months with the highest production, March, July, September and December. This was due to the different research years and seasons that occurred during the study.

The results indicate that the peak fishing season occurs in July and December. Dharmadi & Fahmi (2007) stated that the peak season for catching fish in the Indian Ocean, South Java, can take place from July to September with the peak season in August. The results of Dharmadi & Kasim (2010) also state that the fishing season for Indo-Pacific sailfish on the North coast of Java occurs in September. Prihatiningsih et al (2018) state that the peak season for spot-tailed shark fishing occurs in July and November in the Indian Ocean, South Java, with a base at PPS Cilacap. Dewi et al (2018) state that the peak spot-tailed shark fishing season in East Nusa Tenggara occurs in August and September.

Indo-Pacific sailfish are in demand by both domestic and foreign markets. One market for Indo-Pacific sailfish products is Japan (Sahubawa et al 2006). Indo-Pacific sailfish is used by fishermen around PPN Palabuhanratu as raw material for shredded and other processed products. Although the price is relatively expensive, its distinctive taste and nutritional content causes Indo-Pacific sailfish to be a main choice of clients. The high bycatch of Indo-Pacific sailfish in longline tuna fisheries also occurs in the Pacific Ocean (Widodo & Widodo 2017).

Spot-tailed shark and Indo-Pacific sailfish production and layering in PPN Palabuhanratu need to be managed and utilized optimally, so that it can provide higher economic added value. Information related to production trends and fishing seasons can be utilized by the stakeholders involved in management. Utilization activities carried out must continue to prioritize the preservation of fish resources and environment. In addition, the entry of several spot-tailed shark species as protected species must also be considered.

Conclusions. The highest productivity of spot-tailed shark fisheries in PPN Palabuhanratu occurred in 2016, with 1.2 tons per trip, while for Indo-Pacific sailfish it was 0.35 tons per trip in the same year. Indo-Pacific sailfish and spot-tailed shark fisheries fluctuated every year from 2015-2019, tending to decrease because of overexploitation and the high fishing effort carried out. The pattern of catch for spot-tailed shark in a year is moderate, with 2 peaks in July-August and April-June. The Indo-Pacific sailfish seasonal catch patterns are more diverse, with peaks in July-August and May-June.

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