Fishing gear productivity related fishing intensity and potency of stock vulnerability in Sunda strait

Yonvitr\textsuperscript{1,4*}, E Yuliana\textsuperscript{2}, D E Yani\textsuperscript{2}, L E Setijorini\textsuperscript{2}, Nurhasanah\textsuperscript{2}, A Santoso\textsuperscript{3}, M Boer\textsuperscript{4}, R Kurnia\textsuperscript{4}, S G Akmal\textsuperscript{4}

\textsuperscript{1}Disaster Research Centre (CERDAS IPB). Bogor Agricultural University (IPB University), Bogor, Indonesia
\textsuperscript{2}Department of Biology, Faculty of Sciences and Technology, Indonesia Open University, Indonesia
\textsuperscript{3}Department of Statistic, Faculty of Sciences and Technology, Indonesia Open University, South Tangerang, Indonesia
\textsuperscript{4}Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University (IPB University), Bogor, Indonesia

*E-mail: yonvitr@yahoo.com

Abstract. Increasing of fishing productivity is an indicator of fishing intensity. The increasing productivity dominated by a small and immature population also as an indicator of vulnerability stock in the sea. Therefore, fishing productivity research is important as the basis of the study of the efficiency and vulnerability of fish stocks. This research was conducted in the Sunda strait using landing fish data in Labuan Landing Port from February until July 2018. Evaluation of the effectivity and intensity of fishing pressure was determined by a descriptive statistic from average and deviation of the fishing number. The results of the research showed that the productivity of purse seine, beach seine, mini purse seine, mini trawl was 100.63, 84.16, 25.5 and 31.6 kg per unit per trip, respectively. These gears were more effective compared to other fishing gears. These results can be used as an indicator and basis to evaluate the vulnerability stock from fishing activity.

Keywords: fishing, intensity, Labuan, productivity, Sunda strait, vulnerability

1. Introduction

The success of a fisheries management can be reflected by the benefits that can be obtained by fishermen and stock sustainability. Recently the fisheries business has shown an inconvenient condition because the stock and population were decrease from 2016 to 2018 (Sugandhi 2018). Normally this situation resulted in decreasing of fishermen income and social welfare. Fishermen are poorer than usual, caused stock decreasing.
The decreasing of production caused by skill and knowledge and technology in the fishing process are limited. Therefore not optimal in using fishing fleet, boat dan fishing operation. This could affection will have low production and economy beneficiaries. Another impact of uncontrolled input of fishing activity is the economic benefits. Fisheries artisanal that are mostly filled by small boat usually get the lowest yield.

Even if compared to the minimum living needs often do not meet. For this reason, efforts and solutions are needed to ensure that fisheries provide benefits for economists to fishermen and fishermen families. In the future, the fisheries business must be better planned by measuring the existing potential with the needs of the fishermen needed. So that it can be ascertained that fishermen still benefit from fisheries. Although Indonesia is a tropical country and has various types of fish, in every attempt to catch it there is always no limit between target fish and bycatch. This plan is intended to get better production and efforts to be more effective and efficient.

Production and productivity assessments become indicators assessing efficiency and fisheries program for management. Because of high production without being followed by high production in an area shows the occurrence of excess equipment and capture efforts. For this reason, it is necessary to immediately evaluate and standardize existing tools that can provide better results and production.

It is not easy indeed, but the preliminary effort must go on with the main target of doing business reconstruction that is still in favor of the welfare of fishermen and the sustainability of resources in the future. The study of productivity is important to ensure that fisheries are still providing more benefits and benefits to fisherman and fisheries business actors.

2. Material and methods

2.1. Research Area
The research was carried out in the Banten sea Province, that consist of 4 main locations. The data collecting was done by survey and sampling in four landing port at 4 districts in Banten. There are Tangerang, Serang, Pandeglang, and Lebak Districts. The Tangerang and Serang Districts are represented of northern Banten sea that located in the fishery management area (711 and 572) the Java Sea and northern of Sunda Strait. This area dominated by artisanal fisheries while its fishing ground in the north part of Java Island (Yonvitner, 2007). Other site is Pandeglang that locate in the west Banten and a part of south of the Indian Ocean (FMA 572). The last was Lebak District which located in Indian Ocean or are (FMA 573) as shown in figure 1.

2.2. Data and Analysis
Data collected in this study was fisheries production according to fishing gear every year from annual catches. Data was obtained from field sampling or from statistical data book records of catches of each type of fish, fishing gear, number and size of vessels, fisherman production data and data of effort given by fishermen every year of operations and efforts. The data obtained were analyzed descriptively to estimate fisheries productivity with the equation number 1. The data that needed for this analysis is production data and vulnerability of species.

\[
\text{Productivity} = \frac{\text{Production (kg)}}{\text{Unit Gear (gear,boat,livelihood) (unit)}}
\]  

(1)
Figure 1. The fishing ground of fisherman in northern, western and southern of Banten Sea. Green tick show as Tangerang fishing ground, yellow tick show as Serang fisherman ground, red tick show as Pandeglang fishing ground and orange tick show as Lebak fishing ground (Yonvitner 2019).

2.3. Efficiency and productivity

Recently fisheries management program in many areas still using the common practice of management. In this situation fishing activity regulated by input and output control. Production value is a function of capture intensity, stock availability, the effort, and time of capture. While productivity is a function of production and fishing gear. The relationship between production and productivity can actually explain the level of effectiveness of the fishing gear used by fisherman. Determination of the limits of production value and productivity is done based on the average values and confidence limits by following formulations (Walpole 1992).

Productivity score or Production low, red color, if \( x < \mu - 0.5 \text{ CL} \)  
Productivity score or Production medium, yellow color if \( x = (\mu - 0.5 \text{ CL}) - (\mu + 0.5 \text{ CL}) \)  
Productivity score or Production high, green color if \( x > (\mu + 0.5 \text{ CL}) \)

The technique for evaluating productivity status using a matrix approach technique from productivity score from the formula above. Based on this evaluation of fisheries efficiency, productivity status and production are known. The representation of efficiency status will be described by 3 different colors green (good efficiency), yellow (medium efficiency), and red colour (low efficiency) as describe table below.

| Production | High (score 3) | Medium (score 2) | Low (score 1) |
|------------|---------------|-----------------|---------------|
| High (score 3) | Efiisence very high (score 9) | Efiisence very moderate (score 6) | Efiisence medium (score 3) |
| Moderate (score 2) | Efiisence very moderate (score 6) | Efiisence medium (score 4) | Efiisence low (score 2) |
| Low (score 1) | Efiisence medium (score 3) | Efiisence low (score 2) | Efiisence very low (score 1) |
Green-green color provides very strong relationship information (very high efficiency score 9), high green-yellow color efficiency (score 6), medium green-red color efficiency (3), yellow color with yellow efficiency moderate (score 4), yellow with low efficiency red (score 2), and red with red efficiency very low (score 1). The relationship of color from the matrix and the multiplication approach can be explained that production is high (green), medium production (yellow), low production (red). High gear productivity (green), moderate productivity (yellow), low productivity (red).

The intrinsic vulnerability (or vulnerability to fishing, IV) of each species was obtained from Cheung et al (2007). When species information is not available (poor data) the IV genus was used (Lloret and Font 2013). The index was calculated using a fuzzy logic expert system based on the life history and ecological character of marine fish (Yonvitner et al 2018). The index value range from 1 to 100 with 100 being the most vulnerable. The average intrinsic vulnerability of fish in the catch was calculated from the arithmetic mean of the intrinsic vulnerability index of fish taxa. According to Cheung et al (2005), four categories in relation to levels of intrinsic vulnerability can be distinguished as very high (mode of intrinsic vulnerability at 80), high (mode = 60), moderate (mode= 40) and low (mode= 20).

3. Result and discussion

Research on the status of the fisheries productivity in the coastal area in Banten Province was carried out as an effort to ensure the utilization and fishing rate, obtained by the local fisherman. Fishing activities that take place throughout the day can cause the degradation of fishery stocks in the future.

3.1. Fishing fleet

There were 25 (five) types of fishing fleet scattered in Banten Province. These types of the fishing fleet can be classified into 5 (five) groups. The number of fishing fleet (units) in Banten Province from 2009 to 2017 is described in figure 2.

![Figure 2. Number of fishing units based on the type of fishing gear in Banten province (name of fishing fleet refer as a local name in Banten).](image)

In southern and northern Banten sea, fishing fleet was dominated by gillnet that reaches 42 %, trap about 30%, line 18%, and trawl about 10%. Others fleet operated by fisherman in this area under 10% of the total fishing fleet.

3.2. Production dan Productivity
Determination of productivity level in Banten Province was determined from the average fisheries production that obtained from the data of each district. The average total production of Banten province was obtained at 110,738.7 kg per gear per year. The maximum limit of production per unit of the fleet was about 163,689.1 kg per gear per year and the minimum production level was about 57,788.4 kg per gear per year. Based on these values and limits, the level of production of each year in the Banten is listed in table 2.

| Gear type | Tangerang | Gear type | Serang | Gear type | Pandeglang | Gear type | Lebak |
|-----------|-----------|-----------|--------|-----------|------------|-----------|-------|
| Payang    | 77866.9   | Payang    | 3175.05| Payang    | 3361.83    | Payang    | 280560.3|
| Dogol     | 59272.3   | Dogol     | 579312.62| Dogol     | 2551.70    | Purse Seine| 517341.4|
| Purse seine | 71126.7  | Gillnet   | 20844.42| Gill net  | 3062.16    | Drift Gill Net | 1074311|
| Gillnet   | 83785.5   | Guiding barrier | 151512 | Drift gillnet | 3613.69 | Bottom gillnet | 209440.3|
| Rawai     | 1976.7    | Line      | 29249.8 | Beach seine | 2465.92   | Trammel Net  | 120810.8|
| Hand line | 51762.0   | Bottom gillnet | 56854.02 | Bottom gillnet | 3147.01 | Boat lift net | 134780.4|
| Guiding barrier | 396.3 | Boat lift net | 510972.9 | Boat lift net | 2513.99 | Dredge net | 887.5|
| Trap      | 38338.7   | Stationary lift nets | 54262.17 | Stationary lift nets | 1653.47 | Tuna longline | 326717.4|
| Other fleet | 11084.3 | Floating lift net | 266041.75 | guiding barrier | 114.45 | Others line | 165635.6|
| Other gear | 331.1    | Line      | 2226.76 | Cendor net | 10796.13 | Dredge net | 25410.5|
|           |          |           |        |           |            | Shrimp entangling gill net | 64.18 |
|           |          |           |        |           |            | Seaweed collector | 74579.25|
|           |          |           |        |           |            | purse seine | 38154|
|           |          |           |        |           |            | Drift longline | 142997.4|
|           |          |           |        |           |            | Set gillnet | 689276|
|           |          |           |        |           |            | Others | 90563.25|
|           |          |           |        |           |            | Trap | 3545.5|

Note: Staining the level of productivity is based on the level of the boundary of provincial data. The red color shows the productivity value lower than the minimum limit, the yellow color is at the between the minimum and maximum value and the green color value is above the maximum limit value. Minimum-to maximum limit calculated by statistically process of productivity data.

Production was determined by many factors which are efforts such as the length of operation, capital, and others. Oliveira et al (2009) mentioned it as energy, the number of workers and the area of the treatment area. The production of purse seine and dogol catches were higher than that of other gears. The results of the above grouping show that fisheries production in Pandeglang regency was predominantly classified as low. While the area of Lebak as large still has higher production. Cumulatively production in Lebak was still relatively high from other regions. The consecutive high-yield was payang, purse seine, retained chart, boat chart, dogol, gillnet tramel net drift, and cendor net. Furthermore, the evaluation results on the level of productivity of fishing gear from each region also show a differed in the pattern. The average productivity of the province was 4 698.2 with a deviation of...
3 677.8. Thus, the upper limit of the provincial productivity value was 6 537.1 kg per fleet, and the lower limit was 2 859.1 kg per fleet. From this data, then the productivity level was described as the table 3.

Based on KP No 58 regulations in 2016 that productivity is still diverse. The productivity of payang, purse seine, rawai, and trap are good productive in Tangerang. While based on the value of productivity distribution, only payang and purse seine have high productivity. The fishing gear which is still relatively productive namely purse seine, stationary lift nets and dogol. All fishing gear in Pandeglang is classified as unproductive both from the average catch limit and from the rules set. Whereas for the Lebak region of the fishing gear, purse seine, drift gillnet, tramel net, rawai, cendro, collecting seaweed and fixed gill nets are still relatively productive.

| No  | Fleet               | Serang | Lebak         | Pandeglang | Tangerang |
|-----|---------------------|--------|---------------|------------|-----------|
| 1   | Payang              | 7.07   | 31612.4       | 19.22      | 11.441    |
| 2   | Purse Seine         | 44986.2| 25.50         | 12704      |           |
| 3   | Drift gillnet       | 61.30  | 9231.5        | 17.37      | 483       |
| 4   | Bottom Gillnet      | 23.87  | 683.1         | 18.34      |           |
| 5   | Trammel Net         |        | 12390.8       |            |           |
| 6   | Boat lift net       | 51097.29| 1393.6       | 10.00      |           |
| 7   | Guiding barriers    | 105.85 | 11.6          | 0.00       | 138       |
| 8   | Tuna longline       |        | 2672.5        |            |           |
| 9   | Other line          | 125.17 | 1907.0        | 10.08      |           |
| 10  | Cendro line         | 7557.3 |               |            |           |
| 11  | Shrimp net          | 486.0  |               |            |           |
| 12  | Seaweed collector   | 1346.8 |               |            | 1600      |
| 13  | Drift longline      | 330.8  |               |            |           |
| 14  | Sett longline       | 744.8  |               |            |           |
| 15  | Set gillnet         |        | 1025.7        |            |           |
| 16  | Others              | 16.56  | 695.7         | 1809       |           |
| 17  | Trap                |        | 22.0          |            | 3138      |
| 18  | Danish seine        | 25844.38| 22.33        | 829        |           |
| 19  | Beach seine         |        | 84.17         |            |           |
| 20  | Encircling net      | 100.64 |               |            |           |
| 21  | Stationary liftnet  | 5253   |               | 9.53       |           |
| 22  | Dregde              |        | 12.61         |            |           |
| 23  | Shrimp entangling gill net | | 3.98 |               |            |
| 24  | Mini bottom trawl   |        | 31.60         |            |           |
| 25  | Floating lift net   | 176.77 |               |            |           |
| 26  | Handline            |        |               |            | 330       |

Note: Staining the level of productivity is based on the level of the boundary of provincial data. The red color shows the productivity value lower than the minimum limit, the yellow color is at the between the minimum and maximum value and the green color value is above the maximum limit value. Minimum-to maximum limit calculated by statistically process of productivity data.
The average fish production in Lebak and Serang was higher than in Pandeglang district. Similarly, the productivity in Serang and Lebak was higher than provincial productivity. Pandeglang has low productivity, so many efforts are needed to improve and arrange as soon as possible. The province has productivity level is shown in the table 4.

3.3. Intrinsic vulnerability

Only 14.2% of the species are classified in the higher vulnerability categories (very high vulnerability and high to very high levels) whereas the 38% were classified in the medium vulnerability categories (medium and low to medium) and the remaining 43% presented low-level vulnerability. There are no significant differences in the average intrinsic vulnerability of the fishes obtained from each fishing gear (figure 3). The highest weight of intrinsic vulnerability was gillnet (45.82) line (45.40) and payang (43.44), whereas the lower value was raft lift net (average 35.46). Four fishing gear have intrinsic vulnerability score above from 40.90 were payang, gillnet, encircling gillnet, and line. These fishing gears have potential risk to fish extinction in Sunda Strait.

**Table 4.** Average production (kg per year) and productivity (kg per fleet per year) in each District of Banten Landing Port

| District      | Average Total Production Per year (Kg) | Average total Productivity per year (kg/gear) |
|---------------|----------------------------------------|---------------------------------------------|
| Tangerang     | 43,956.6                                | 3,607                                       |
| Serang        | 167,255.6                               | 8,271                                       |
| Pandeglang    | 1,989.4                                 | 26                                          |
| Lebak         | 229,753.3                               | 6,888                                       |
| Provinsi Banten | 110,738.7                              | 4,698.2                                    |
| STDEV         | 105,900.7                               | 3677.86764                                 |
| 0.5*STD       | 52,950.37                               | 1838.93382                                 |
| Up to Level   | 163689.1                                | 6537.1                                     |
| Low Level     | 57788.4                                 | 2859.2                                     |

The results from table 4 were used to determine boundaries and map fishing fleet that was classified as efficient, less efficient and inefficient.

![Figure 3](image-url) **Figure 3.** The vulnerability of each fishing fleet
Discussion

Research on fisheries productivity is very important for fisheries (sustainability) and developing fisheries management plans (Pan and Walden 2015). In Banten sea, some fishing gears operate at night to catch positive phototaxis fish. The fishing technique usually have no potential risk for overfishing or overexploited. Unexploitative gear, so it is not at great risk of accelerating fisheries business collapse (Branch 2008). Fisheries practices with many fishing gears in one area of fisheries utilization and include a form of co-management business need to be managed properly to ensure the sustainability of fisheries stocks. Pomeroy et al 2010 stated that the practice of using multi-scale, multi-gear, multi-species fisheries can be used to develop the concept of ecosystem-based fisheries. Changes in fisheries management practices from multi-sector to coordinative at the provincial level could increase efficiency and productivity due to increase productivity (Torres et al 2014)

The implementation of Law No. 1 of 2014 concerning coastal management which gives authority to the province, could provide a better guarantee of fisheries business governance. So that the practice of transboundary management between municipal districts does not stand out, this increasing productivity. Transboundary management practices like in the BoBLME area of Andaman sea in Bangladesh (Akester 2018) caused a decrease in productivity. The conditions will be different from Indonesian fisheries so that low productivity in some regions can be increased. Changes in productivity towards a better condition support fisheries industrialization (Oliveira et al 2009).

Transition management stage in implementing of Law No 1 of 2014 potential drive the increase of risk and vulnerability of stock. The intensive exploitation of fishing fleet causes a potential risk of global extinction in Sunda strait. Productivity and susceptibility analysis approach by Yonvittner et al (2013) found the species at high risk were goldband goatfish (Upeneus mollucensis; 1.42 score), red bigeye (Priachanthus tayenus; 1.39 score), japanese thread fin bream (Nemipterus japonicas; 1.31 score), indian mackerel (Rastrelliger kanagurta; 1.20 score), and sardine (Sardinella fibriata; score 1.04; Puspita et al, 2017). Lloret and Font (2013) found that spearfishing (54.15 score), and longlining (53.19 score) and gillnet vulnerability in the Mediterranean were higher than gillnet and line gear in Sunda Strait. Differences and changes fishing technology increasing fishing capacity (Kalikoski et al 2010) and potentially to increasing the vulnerability of stock (Dulvy et al 2003) vulnerability (Sanchez et al 2014). Cardinale et al (2011) showed that the purse seine fleet has increased the number of days spent at the sea for each trip in the attempt to expand into more distant fishing grounds as a result of reduced catches on grounds previously exploited in the Java Sea. These research has shown that fishing activity in Sunda strait also in threat and potentially at a high risk of vulnerability.

Good management practice is needeed to reduce risk and vulnerability and increase should be created in productivity. Good control and regulation to control input in fisheries production. In this case its important to increase monitoring and control of the fishing program to ensure sustainability stock for our future.

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