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Condition and Status of Shrimp Fisheries in West Papua Province: Case from Bintuni Bay Regency, Sorong City, and South Sorong Regency

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The aim of this research was to determine the condition and status of shrimp fisheries in Bintuni, Sorong, and South Sorong Regency. This research was conducted from May to July 2019 in the center of the shrimp industry. Variables measured in this study include the status of shrimp fisheries, shrimp fisheries production data for 10 (ten) years, conditions of shrimp availability, size, and type of shrimp obtained through interviews using questionnaires used to obtain an overview of shrimp stock conditions in nature. Analysis of the estimation of potential shrimp resources using the surplus production method from FAO (Food Agriculture Organization). Surplus Production is based on the assumption that Catch per Unit Effort (CPUE) is a function of f (catching effort/effort) which is linear. Data analysis, it was found that the highest number of shrimp catches occurred in 2010-2015, while the status of shrimp fisheries from the maximum sustainable yield (MSY) was 10,943.1 tons per year. Based on data collected for 10 years, from 2010 to 2020, the number of shrimp catches in the waters of Bintuni Bay and South Sorong has not exceeded the value of shrimp sustainable potential. The highest shrimp catch in the waters of Bintuni Bay and South Sorong occurred in 2015, which was 5,473 tons. The utilization rate of shrimp in the waters of Bintuni Bay and South Sorong is 5,473/10,943.1 which is 50.01%, respectively. Based on calculations using the catch effort data analysis package (CEDA 3.0), the value of the catchability coefficient (q), intrinsic growth rate (r), and carrying capacity (k) are used to determine the population growth rate. In equilibrium condition, when the growth rate is equal to zero, the shrimp population is equal to a carrying capacity of 15.519,9 tons per year, respectively.

Keywords: Conditions and status; shrimp; fisheries; West Papua.

1. INTRODUCTION

Illegal fishing, unreported, and unregulated in Indonesia has been very detrimental. Illegal fishing is carried out by foreigners or by Indonesian citizens themselves in various ways such as falsifying documents, transferring fish without a license, using chemicals, and explosives, or using materials or tools that endanger resources that are not by law Number 31/2004, Law number 45/2009 concerning fisheries [1]. Article 8 paragraph (1) of Law Number 31/2004 states that every people is prohibited from fishing and or fish farming which was using chemical material, biological material, and explosives endangering the sustainability and or environment at the fisheries area Indonesia. Law number 45/ 2009, mandate that criminal in fisheries area has to be resolved through fisheries court. Furthermore, damage due to illegal fishing reached $US 300 billion per year, which reached 25% of Indonesia's total fisheries potential [2]. The damage also threatens the sustainability of marine and fisheries resources [3,4].

The Indonesia Ministry of Marine Affairs and Fisheries, which was responsible for managing marine and fisheries resources made efforts by issuing a moratorium policy on ex-foreign vessels whose manufacture abroad, prohibited used shrimp trawl and transshipment through the Minister of Marine Affairs and Fisheries Regulation number 56/2014 and number 58/2014 about forbidden transshipment practice. The substance of the regulation prohibited ex-foreign and transshipment from operating in all areas of Indonesia water starting from November 3th to April 30th, 2015, and then the serious step was continued with regulation number 10/2015 about the extension of the moratorium policy which adds term the period of cessation of ex-foreign vessel operation until October 31th, 2015 [2].

West Papua is one of the provinces that has a large marine area with high marine biodiversity. West Papua has a 104.772 km^2 area with a coastline of 12.053,46 km and has 3146 small islands identified [5]. This potential is very important for increasing the production of fishing fisheries especially in West Papua Province. Fisheries and marine products, including shrimp commodities, are one of the best products for driving the regional original revenue of West Papua Province. The Regional revenue sourced from local property taxes and retribution for certain licenses in the marine and fisheries sector in West Papua Province in 2019 amounted to $ US 235,14, ranked second level after the Samsat sector [6].

In other fish commodities, shrimp was the superior commodity and has a high export value [7,8]. So many fishermen catch shrimp in West Papua Province. The shrimp potential of Bintuni Bay Regancy is around 291 tons per year and

South Sorong Regancy is around 3.861 tons per year [5]. In 2019, shrimp production at Bintuni Bay Regancy was 420 tons, and South Sorong Regancy was around 2.431 tons [9]. Shrimp fisheries are the leading sector with a large contribution to economic growth in the region [10,11]. The role of the fishing industry is very important to accelerate economic development in West Papua Province, thus requiring good management for managing potential shrimp fisheries and the status of shrimp fisheries in West Papua Province [12]. Furthermore, [13] shows that shrimp fisheries in West Papua need to be controlled to ensure that the utilization of shrimp resources is carried out in a sustainable manner. One of the controls carried out is to determine the number of catches per unit of effort and the maximum sustainable yield (MSY) [14-16]. Biological reference points are used as instruments in assessing fishery resource stocks [16]. In the management of fisheries, it's necessary to consider the impact on the ecological and socio-economic aspects so the sustainability of shrimp fisheries in West Papua Province can be achieved. Lack of information about the optimal utilization of shrimp fisheries can cause shrimp fisheries to collapse. Therefore, information of shrimp stocks is needed to ensure sustainable use of shrimp fisheries. So, this study aims to determine the condition and status of shrimp fisheries at Bintuni, Sorong, and South Sorong Regency of West Papua Province. By knowing the condition of shrimp stocks, the utilization of shrimp can be carried out properly and effectively in the future.

2. MATERIALS AND METHODS

2.1 Time and Location of Research

This research was conducted from May to July 2019 in three locations Bintuni Bay, South Sorong, and Sorong Regency (Fig. 1). The research locations of South Sorong were in Konda and Wamargege waters, which were shrimp fishing areas. The research location of Bintuni Regency was conducted in fishermen's village (East Bintuni District, and Sido Makmur village) as well as the location fisheries company that PT Timika Samudera, PT Harda Indo Perkasa and PT Holi Mina Jaya. The research location of Sorong City was conducted in Sorong Fisheries Port, Fish Quarantine Station, and fisheries companies (PT AFKE, PT WIFI, PT IMPD).

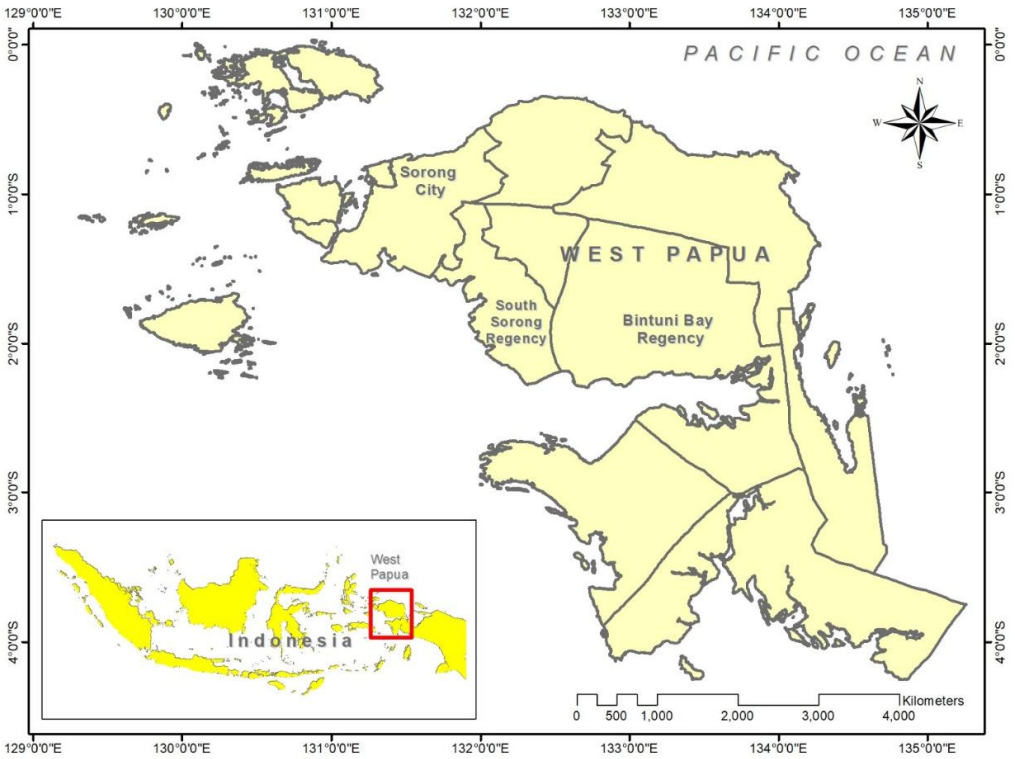

Fig. 1. Map of Research Location

Two types of data were collected, that are primary data and secondary data. Primary data was obtained through observation and interviews. The observation was intended to obtain an overview of shrimp fishing activities in the research location. Interviews were intended to obtain information from respondents involved in shrimp fisheries production and consumption activities guided by list questions (questionnaires) that have been prepared according to the researched objectives. The variable measured in this study included the status of shrimp fisheries, shrimp fisheries production data for ten years, condition of shrimp availability, size, and varies of shrimp obtained through interviews using questionnaires which were will use for obtaining an overview of the condition shrimp stock in nature.

2.2 Data Analysis

This research was directed to obtain data on shrimp potential for estimating the value of shrimp sustainability in West Papua Province included in the Fisheries Management Area (FMA). The research data were analyzed using ecological analysis. To estimate the ecological potential of shrimp commodities, the maximum allowable catch and the potential amount of shrimp were used. Analysis of the estimated potential shrimp potential using the surplus production method from FAO. Surplus Production is based on the assumption that Catch per Unit Effort (CPUE) is a function that is linear. Data processing to perform CPUE analysis using Microsoft Excel software and catch effort data analysis using CEDA 3.0 package. CPUE analysis can be calculated using the equation below;

$$\mathrm{CPUE} = \frac{a}{f} \quad (1)$$

So:

$$\frac{c}{f} = a - b \quad (2)$$

$$\mathrm{MSY} = \frac{a^2}{-4b} \quad (3)$$

$$f_{optimum} = \frac{a}{-2b} \quad (4)$$

Calculation of shrimp utilization rate uses the formula below, namely:

$$\text{Utilization rate} = (Ct/MSY) \times 100\% \ldots\ldots \quad (5)$$

Note: CPUE = cache per unit effort C = catch; f = catching effort/effort; Ci = number of catches period I; MSY = sustainable potential

The CPUE value was calculated after standardizing the fishing gear. The standardizing fishing gear has a fishing power index (FPI) value equal to 1 (one).

3. RESULTS AND DISCUSSION

3.1 Production of Shrimp in West Papua

Indonesia's shrimp production determines the large export offers of shrimp to destination countries [17]. One of the best fisheries commodities is shrimp. Shrimp is recorded at the second rank of Indonesian fisheries export after tuna, mackerel, and skipjack with a volume of around 11.15% and the value export reached 33.10% [18]. Indonesia is one of the largest shrimp exporters in the world. West Papua in particular is exported in the form of frozen shrimp. Several publications support this statement, for example in Papua waters [19-22] and other Indonesian waters [23-31]. Furthermore, shrimp exports from Indonesia are widely marketed abroad in various countries [32].

Fisheries is one of the subsectors that plays a role in the national economy. This subsector encourages the growth of agribusiness through the supply of raw material, increases foreign exchange through the export of fisheries product, provides employment, increase fishermen's income, and contributes to increasing Gross Domestic Product [18]. The constant price at 2000, there has been an increase in the fisheries subsector PDB over the last 5 years with a growth rate of around 6.82% that higher than the national GDP growth of around 5.06% [33]. West Papua was the one of provinces that produced shrimp with export targets. Production of shrimp in West Papua from 2010-2020 (Fig. 2).

3.2 Shrimp Fisheries in Bintuni Regency

Referring to information obtained from the interview and direct observations, the main shrimp caught by fishermen is penaeid shrimp (*Penaeus merguiensis)* and dogol shrimp (*Metapenaeus ensis*), which were found in Taroy, East Bintuni, and Sido Makmur Village. The shrimp were obtained using Trammel Net or three-layer nets. Shrimp were an important commodity at Bintuni Regency. Shrimp productivity on one trip reached around 21 kg per

trip. Mangrove crab productivity on one trip reached around 100 kg/trip. The range of jerbung shrimp caught in the water of Bintuni Bay with a carapace length of 4.5 – 10.75 cm. The dominant shrimp length caught is around 6.25 – 7.15 cm [34]. The length analysis of the first caught penaeid shrimp (Lc) was 6.91 cm. The value of Lc has the meaning for fish and shrimp resources because the fish and shrimp that had a length below the Lc are forbidden to catch by fishermen and can grow big size [35]. The first maturity of jerbung shrimp is in the range of 3.38 cm [36,37]). The penaeid shrimp was caught by fishermen already in the state of mature gonad condition. Analysis of the length of penaeid shrimp first caught (Lc) was 14.21 cm.

3.3 Shrimp Fisheries in South Sorong Regency

Penaid shrimp (*Penaeus murgensis)* was the dominant catch using trammel net around 12.56 kg (29 %) of the total catch. White snapper (*Lates calcalifer*) and mackerel (*Rastrelliger* sp) were dominant by-catches using trammel net at South Sorong District. The different lengths of penaeid shrimp (Fig. 3). Furthermore, based on Baseline Survey Report USAID SEA Project 2017, reported that the range of jerbung shrimp that can be caught in the water of the South Sorong district had carapace lengths of around 28.45 – 49.6 mm. Analysis of the length of penaeid shrimp first catch or length at first capture (Lc) was 33.5 mm. The Lc value has meaning that fish and shrimp which had a length below the Lc value will be forbidden to catch and can grow bigger [35]. The growth depends on many factors like optimum temperature and availability of food in the waters [38-40]. Every fish species had a different optimum temperature for growth. However, at least the fish that had below Lc were given the opportunity for growth so that fish can be caught at a certain size. The mean length-at-first capture (Lc) was found to be lower than the mean length at sexual maturity [41-43] dan shrimp population dynamics [44].

Penaeid shrimp at Bintuni Regency (the nearest district from South Sorong Regency) for the first maturity of around 33.87 mm [36] (Sumiono 1983). Furthermore, around 62.7% of penaeid shrimp were caught by fishermen using trammel nets at South Sorong Regency in the condition of the mature gonad. The maturity of the gonads is related to the size of the shrimp caught. This means that the shrimp caught during the spawning period will greatly affect the existence of shrimp stocks in the waters. This condition must be managed properly by paying attention to the size of the shrimp caught. Setting the size of the shrimp caught has been carried out in various countries to maintain stocks of shrimp in nature that can be available at any time [41,42] (1,2), through the selectivity of fishing gear [43-45].

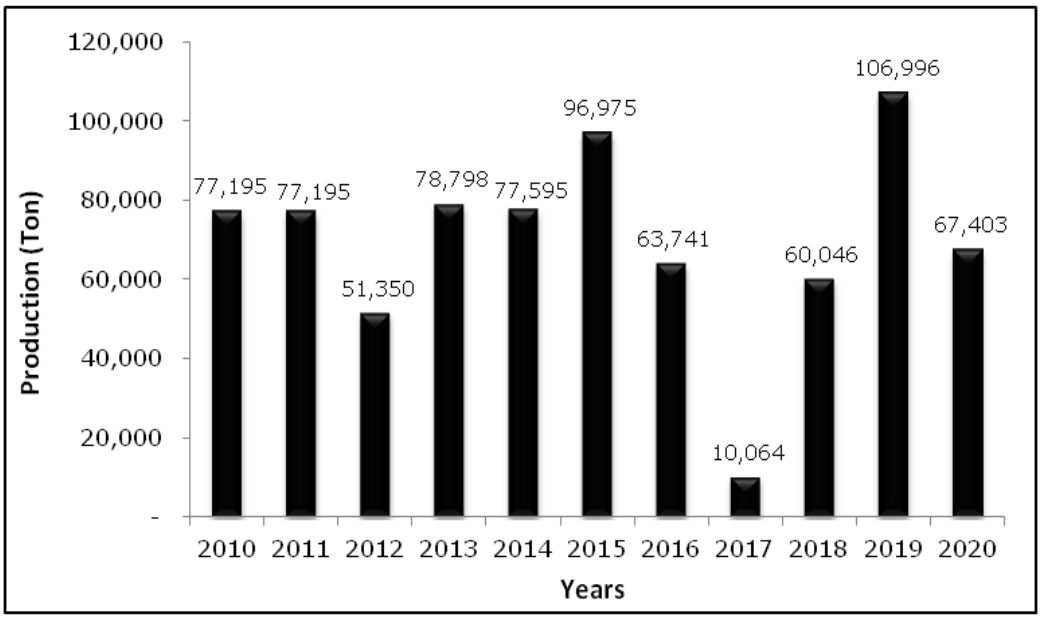

Fig. 2. Shrimp production in West Papua Province (Statistics Central Bureau of West Papu Province, 2010-2020)

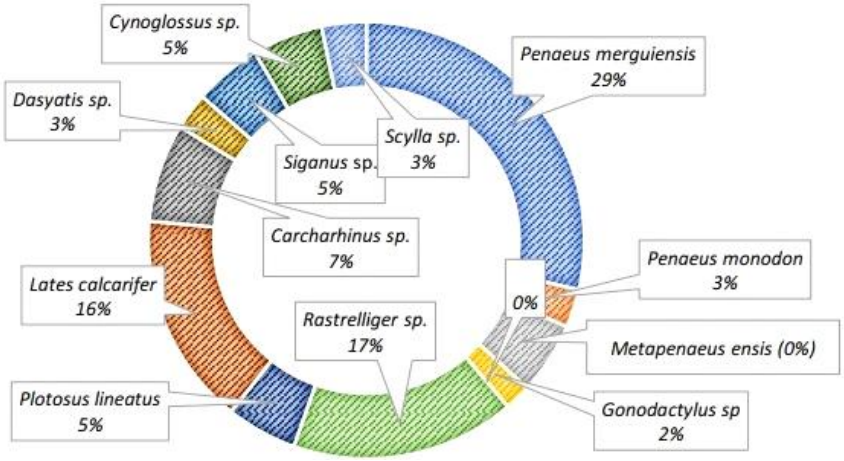

Fig. 3. Composition of Catch Yield fishermen using Trammel Net (Baseline Survey Report, USAID SEA Project 2017)

3.4 Shrimp Fisheries in Sorong Regency

Shrimp fisheries in the Sorong Regency are more likely dominance by shrimp companies or collector shrimp companies. Fish-holding companies in the Sorong Regency generally operate normally [46]. The product was lema fish (*Rastrelliger* sp), tuna fish (*Thunnus* sp), snapper red (*Lutjanus* sp), Mackerel (*Scomberomus* sp), pomfret fish (*Pamphus* sp) and shrimp (*Penaeus* sp). Generally, all companies had markets outside Papua and were not destined for domestic needs. The fishing company had a license from the Ministry of Marine Affairs and Fisheries with a catchment area generally in South Papua waters. Violations of shrimp fishing permits are common in Indonesia [47], but it also happens in many countries [48-50]. This violation can occur in many aspects, such as illegal fishing, unreported and regulated. This condition must be managed both at the scale of traditional and commercial shrimp fisheries.

The respondent company in this research is PT Dwi Bina Utama (DBU). That is because some company doesn't provide data. The reason is that it closed the company. The closed company were PT Irian Marine Product Development (IMPD) and PT West Irian Fishing Industries (WIFI). This day, PT DBU is at the survey stage according to the letter from the Indonesia Institute of Sciences for operating fishing shrimp at Fishery Management Area (FMA) 718. PT DBU is a fishing company, collecting and processing shrimp. The company used shrimp trawl with the fishing area were Arafura Sea and South Papua waters. The main target market is Singapore, Japan and Taiwan.

3.5 Status of Shrimp Fisheries within Research Locations

The potential estimation, allowable catches, and utilization rate of shrimp resources at the study location are needed for supporting policy fisheries management. The potential estimation, the catches, and the utilization rate of shrimp resources at the study location are used as the main consideration in determining the formulation for allocating shrimp resources. The shrimp fishing area in this study at FMA 715 covers Tomini Bay, Maluku Waters, Halmahera Waters, Seram Waters, and Berau Waters. Some shrimp company operated in FMA 718 which cover Aru Waters, Arafuru Waters, Eastern Timor area.

Based on the Decree of the Ministry of Maritime Area and Fisheries Indonesia number 50/KEPMEN-KP/2017 about the potential estimation of allowable catch and utilization rate of fish resources at the fisheries management area of the Republic of Indonesia, it's known that the total sustainable potential of penaeid shrimp in FMA 715 is 6.436 ton with allowable catch is 5.149 ton. The utilization rate of shrimp in FMA 715 is 0.78 which was included in the fully exploited category in meaning that fishing efforts can be maintained with strict monitoring. Based on the calculation of the effort value and the number of catches each year, the CPUE value fluctuation from 2010-2020 can be seen (Fig. 4). Fluctuation in CPUE value obtained based on the catch and the trip on small-scale fisheries operating in FMA 715.

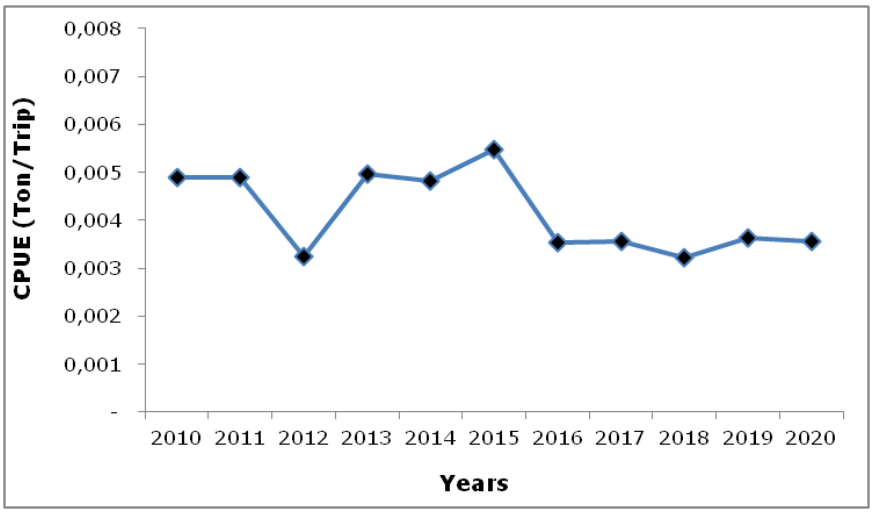

Fig. 4. Fluctuation Chart of shrimp CPUE at study location from 2010 to 2020
(Data source: Central Bureau of Statistics and West Papua of Maritime and Fisheries Services)

The productivity level of fishing gear can be estimated by looking at the relationship between catch and effort called catch per unit effort (CPUE). This CPUE is one of the indicators for the status of the fish resources, so the description of CPUE trend from a fishery is one of the health of fishery statue [51,52]. Based on Fig. 4, it's known that the highest number of shrimp catches occurred in 2020 – 2015. The use of classic surplus production models in stock assessment is carried out with the assumption that the status of resources is in the balance condition, but fish stocks are generally in an unstable or non-equilibrium condition. This unstable condition is characteristic of a population that tries to be adaptive to changes in natural mortality caused by fluctuation and changes environment [53-55].

Shrimp fisheries at Bintuni Bay Regency and South Sorong Regency which included FMA 715 still at the development level. This is indicated by the amount of predicted catch still increasing as the amount of catch effort per year increases. The mean is, if there is an increase in the amount of catching effort through the addition of fishing fleets in small-scale fisheries, it can still be done. The addition of the fleet can be done by conducting strict monitoring because FMA 715 is in the fully exploited category. The increase of effort can be stopped or reduced if it will or has reached an equilibrium point, namely the balance point between effort and predicted shrimp sustainable potential. The equilibrium curve of shrimp catch in Bintuni Bay and South Sorong (Fig. 5).

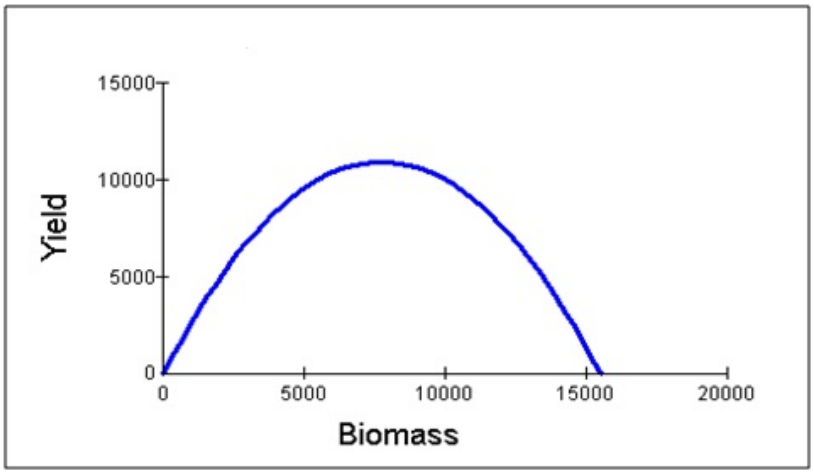

Fig. 5. Equilibrium curve of Catch Yield in Bintuni Bay and South Sorong Regency

The graph in Fig. 5 shows that that the value of maximum sustainable yield is 10.943,1 ton per year. Based on data obtained for ten years, from 2010 to 2020, the catch yield of shrimp at Bintuni Bay and South Sorong not yet pass the value of sustainable yield shrimp. The highest catch yield at Bintuni Bay and South Sorong occurred in 2015 around 5.473 tons. Thereby, the level of utilization of shrimp at Bintuni Bay and South Sorong is 5.473/10.9431,1 is 0.5001 (50,01%). The number of catch yields has decreased due to fishing boats that operate having small capacity because it's dominated by small fishing boats. The highest catch yield in 2019 was around 1.750 tons. So the utilization of shrimp at Bintuni and South Sorong is 17.50/10.9421,1 is 0.1599 or 15.99%. Based on a calculation using catch effort data analysis (CEDA 3.0), the value of catchability coefficient (q), intrinsic growth rate (r), and carrying capacity (k) is used for determining the population growth rate. The equilibrium level is the condition when the growth rate is equal to zero, the shrimp population rate is equal with a carrying capacity is around 15.519,9 tons per year.

4. CONCLUSIONS

Based on this study, condition, and shrimp status at West Papua (Bintuni Bay, South Sorong, and Sorong Regancy) can be concluded that the sustainability yield at Bintuni, South Sorong is 10.943,1 tons per year with the highest catch yield occurring in 2015 around 5.473 ton, thereby the utilization of shrimp sustainability at Bintuni Bay and South Sorong is 50%. The utilization is abaut 15.99%, and the sustainability of shrimp in Bintuni and Sorong South is still abundant.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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