Management of sustainable fisheries and utilization status of red snapper \((Lutjanus\ spp.)\) using handline landed in archipelagic fishing port of Brondong

B Nugraha\(^1\), S W Utomo\(^1\), and I J P Dewi\(^2\)

\(^1\)Sekolah Ilmu Lingkungan, Universitas Indonesia, Salemba, Central Jakarta 10430, Indonesia
\(^2\)Politeknik AUP Jakarta, Pasar Minggu, South Jakarta 12520, Indonesia

Email: Suyud.si@ui.ac.id

Abstract. Fish resources of the study were landed in the Archipelagic Fishing Port of Brondong and it is dominated by the demersal fish (bottom). The red snapper \((Lutjanus\ spp.)\) is one of demersal fish that is found in the Archipelagic Fishing port of Brondong. There is a catch on the red snapper \((Lutjanus\ spp.)\) that takes place continuously without good management. This condition can impact to the decline or fullness of the number of its population, it is necessary to have a review to suspect the potential of sustainable catch and the number of total allowable catch, and the number of total allowable efforts in the management of the sustainable fishing commodity of red snapper \((Lutjanus\ spp.).\) The data analysis method used is the production surplus model. The result of this research showed that the potential for maximum sustainable catch \((Y_{\text{MSY}})\) is 102.88 tons/year and total allowable catch \((\text{TAC})\) is 82.31 tons/year. Maximum sustainable effort \((f_{\text{MSY}})\) is 709 trips/year and total allowable effort is 242 trips/year. utilization rate is 75% where condition in status fully exploited.

1. Introduction

East Java province is known to have fishery potential that plays an important role in economic development, one of which is archipelagic fishing port of Brondong has a very strategic role in the business of developing fishing catches that is as a center or center of marine fishery activities, especially in the Lamongan District of East Java Province. East Java Sea fishery production mainly comes from demersal and small pelagic fish resources, especially demersal fish is an important fish resource in the Java Sea [1,2]. Lately the utilization of demersal fish resources as well as fishing activities are growing rapidly, in general the rate of demersal fish catch has increased significantly in the period 1980 - 1990 after which the rate of fishing has decreased[3].

Demersal fish source commodities are very potential and have high economic prices, one of which is red snapper. Red snapper \((Lutjanus\ spp.)\) is a fish that has a wide habitat. This fish can live in tropical and subtropical waters, at a depth of about 100 meters with coral reef habitats and also sandy bottoms[4]. The Java Sea is one of the most oftentimes caught areas for this species in Indonesia. One of the high red snapper \((Lutjanus\ spp.)\) production in Indonesia is in Lamongan District which
contributes to the fishery sector amounting to 15 until 25% of the total fish production in East Java the Lamongan District of East Java Province [5].

Red snapper is a commodity of high economic value marine fisheries resulting in high fishing of this type of fish. To maintain its sustainability in nature, fishing activities must be regulated which is one of the efforts that can be made to support the conservation of marine biological resources red snapper is a commodity of high economic value marine fisheries resulting in high fishing of this type of fish. The high demand for various types of fish causes an increase in fishing efforts, this leads to the occurrence of more fishing symptoms [6,7]. Based on the annual statistics report archipelagic fishing port of Brondong, there are several fishing gear operating in archipelagic fishing port of Brondong, such as handline, gillnet, longline, cantrang, and the other fishing gear to catch demerseal fish especially red snapper. The dominant and effective fishing gear used to catch red snapper is handline. Hand line is one type of fishing gear that is often used by fishermen. The main structure of the hand line fishing gear consists of a fishing rod, swivel, fishing line, ballast and bait [8]. This fishing gear has a significant role in producing demersal fish, especially landed in archipelagic fishing port of Brondong Brondong. One of the causes is due to the pressure of fishing effort caused by the high number of trips. To overcome the symptoms of overfishing, it is very important to make management fishing efforts considering the nature of fish resources although renewable, but the capability of nature to renew this is constrained which may also end result in the capture of extra fish resources that reason a minimize or loss of manageable from existing fish resources[7].

Fishing resources have been under fishing pressure which has caused total catches to decrease [9,10].The trend of catches suggest that over time by time most assets resources will be over-exploited and can collapse [11]. The potential of fisheries can provide optimal benefits always or sustainably, if managed properly and responsibly [12]. An increasing number of larger and modern vessels and fishing gear are the main causes contributing to the overfishing, illegal fishing, the theft of fish resources, as well as fishing in ways and destructive tools of fish resources [13, 14].

Based on data from the catch fishery Archipelagic Fishing Port of Brondong total production quantity of red snapper (Lutjanus spp.) caught by handline in 2019 is 119,88 kg, whilst in 2018 that is 220,49 kg which means that red snapper production decreased by 46%. In general, red snapper production from year by year decreased, production decreased by an average of 26% per year over the last 5 years. Red snapper fishing efforts caught by handline from year by year an average increase of 28% per year over the last 5 years, so this is the reason for the need for analysis of the potential and utilization status of red snapper caught by handline landed at the Archipelagic Fishing Port of Brondong. The continuous fishing of red snapper without good management can lead to a decrease in the population. Therefore, a management is wished in the limit of red snapper fishing effort so that the fishery sources can be utilized optimally and continue to be sustainable.

2. Materials and methods
The method used in this research was descriptive quantitative method. We processed fishery statistics data in the form of numbers, as well as using a holistic model approach. The method of data analysis with the approach of production surplus model is one of the approaches that can be done in the management of red snapper fish resources in Lamongan Regency. The model of surplus production as a way for managing data on limited fish resource stock or biomass [15]. The surplus production model is one of the simplest and easiest stock assessment models and can be accepted by the fish resources management. Experts state that this model is overly simplifying the processes that occur (over-simplified). This model requires only secondary data, there are catch and effort data, two types of data that have been collected and known as fisheries statistics [16]. Surplus production models are characterized by increased levels of complexity applied to fishery commodities to assess the status of stock or biomass at this time which can later be used as a reference in conducting management of fisheries [17]. This method of supruls production can be used in the suspect suspected the potential of
sustainable catches and the amount of catch allowed in the management of sustainable capture fisheries in red snapper (*Lutjanus spp.*) in Lamongan Regency, so that the preservation of fish resources is maintained.

2.1. CPUE (catch per unit effort)
Standardization CPUE (catch per unit effort) is a fundamental component in the stock valuation of fishery resources. In the capture of multispecies fish resources, capture power can differ depending on which species are the main target, so annual trends from standardized CPUE data tend to be inappropriate. Many attempts in fisheries to catch many species using one fishing gear. When fishermen target the main target of certain species in conducting fishing efforts, they can get bycatch which is not a target fish. Therefore, the proper use of fishing gear must depend on the target species that they want to catch [18].

We used time series data for ten years, obtained from 2010 to 2019. Data on catches and efforts were obtained from Archipelagic Fishing Port of Brondong, and then we calculated the value of the catches per fishing effort (Catch per Unit Effort). The formula used to recognize CPUE values is as follows [19]:

\[
CPUE_i = \frac{\text{catch}_i}{\text{effort}_i}
\]  

(1)

Description: \( CPUE_i \) = catch per fishing effort in years-i (Ton. Trip\(^{-1}\)), \( \text{catch}_i \) = catch result in years-i (ton), \( \text{effort}_i \) = fishing effort in years-i (trip). The catch per unit effort (CPUE) must be applied so that the effort and catch can be appropriately approved, with controlled or regulated catches it is easy to obtain the required data [20].

2.2. Estimation of sustainable potentials
The maximum potential of sustainable or we called it as Maximum sustainable yield (MSY) is an effort to capture that can produce maximum catches sustainably without affecting the productivity of stocks or biomass in the long-term [21]. The term maximum sustainable yield (MSY) is based on capturing the maximum total of fish resources safely from the amount of stock that is still available by maintaining its capacity to obtain sustained catches in the long term [22]. Maximum sustainable yield (MSY) refers to a state of equilibrium between a population of exploited fish resources and fishing activities.

If stocks are still not exploited or slightly exploited, a maximum target of between half and two-thirds of MSY's estimates can be set as the initial catch rate to be used in planning the development process. However, if the stock has been exploited at a fairly high level, it also estimates MSY and set the level of \( F_{MSY} \) (\( \frac{2}{3} \) of MSY), input must also be given to capacity increases or decreases in the number of fleets and the likelihood of impact of changes in catch level [23].

Regression analyses between CPUE and the number of attempts that will eventually form the equation:

\[
y = a + bx
\]  

(2)

Description: \( C = \) Catch, \( F = \) Fishing effort (Effort), Optimum effort value \( (f_{opt}) \) is:

\[
f_{opt} = -\frac{a}{2b}
\]  

(3)

The results of the catch at the optimal stage of effort to be achieved a MSY state can be calculated through the formula:

\[
MSY = -\frac{\frac{a^2}{4b}}{1}\n\]  

(4)
Description: \( a = \) Intercept, \( b = \) slope, \( MSY = \) maximum sustainable yield, \( f_{\text{opt}} = \) number of optimal capture tools

2.3. Total allowable catch (TAC)

One of the main challenges in sustainable fisheries management is to determine the right framework in its implementation, resource conservation, and fisheries resource management which depends on the utilization of its resources. One of them by limiting the amount of catch allowed to reach the goals in sustainable capture fisheries management. Total Allowable Catch (TAC) is a permissible catchment limit on the fishery resources applicable to the specified time period. TAC is used to limit the capture of a particular fish resource which is a technique in managing fish resources [24]. The potential of marine resources that are permitted to be utilized is only about 80% of the maximum sustainable catch (MSY). The basic utilization of potential can be arrested Total Allowable Catch (TAC) amounted to 80% of MSY [25]. To calculate TAC using the formula:

\[
\text{TAC} = 80\% \times MSY \quad (5)
\]

Overfishing is a condition when TAC values is greater than MSY values. Besides, when TAC values MSY values, it means fishing can still be increased to get more capture, but does not exceed the limit of MSY values that is already determined.

3. Result and discussion

3.1 CPUE analysis

Number of catch and effort standards in arrest red snapper that landed in Archipelagic Fishing Port of Brondong using fishing gear handline obtained data from the arrest effort union (CPUE). The catch per unit of efforts (CPUE) is obtained from the division between the number of catch (ton) and the number of fishing effort (trip) standard capture fishing equipment. The catch per unit efforts (CPUE) from 2010 to 2019 was presented in Figure 2.

![Figure 2. Number of catch and fishing effort](image)

![Figure 1. Catch per Unit Effort 2010-2019](image)

In Figure 2 can be seen the value of catch per unit effort (CPUE) obtained from the division between the number of catches and the fishing effort. The highest value of catch per unit effort (CPUE) occurred in 2017 with a value of 0.472 tons per trips with the number of catches of 53.38 tons and the number of trips fishing effort is 113 trips. The lowest catch per unit effort (CPUE) occurred in 2011 with a value of 0.011 tons per trip with the number of catches of 3.8 tons and the number of trips fishing effort of 342 trips. The slight value of CPUE is indicated by the decrease in the number of catches and the increasing number of fishing efforts. Catch per unit effort will tend to show a decrease, this decrease can be easily explained by increased fishing efforts and increased catches [18].
3.2 Estimating the potential of maximum sustainable yield and total allowable catch

The estimation potential of sustainable catch consists of the estimation of Maximum Sustainable Yield (MSY) and the estimated number of total allowable catch (TAC). Estimation of MSY using catch and the number of fishing effort standard, using the data can be known value of catch per unit effort (CPUE) to do linear regression with variable Y = catch per unit effort (CPUE) and variable X = effort (trip).

\[ y = -0.0002x + 0.29 \]
\[ R^2 = 0.1237 \]

![Figure 3. CPUE's relationship with efforts](image)

The picture above shows that the increasing efforts to catch red snapper (*Lutjanus spp.*), the catch per fishing effort will decrease. From the results of linear regression analysis between fishing effort variable (X) with value of catch per unit effort (CPUE) as dependent variable (Y) obtained from the following equation: catch per unit effort (CPUE)= 0.290 - 0.00020f.

When it reaches the MSY (Maximum Sustainable Yield) point, if the effort continues to be increased then the catch will decrease or run out.

![Figure 4. The association between an effort and catch](image)

Analyst results obtained maximum sustainable effort (f<sub>MSY</sub>) of 709 trips per year, and the maximum sustainable catch (Y<sub>MSY</sub>) of 102.88 tons per year. Looking at the number of total allowable catch (TAC) is 80% of MSY, the result is 82.31 tons per year with the number of total allowable effort is 242 trips per year. From the results of the analysis above, the level of utilization red snapper (*Lutjanus spp.*) in Archipelagic Fishing Port of Brondong can be estimated by comparing between the average value of catches over the last ten years is 76.71 tons per year with the value of the number of maximum sustainable catch (Y<sub>MSY</sub>) is 102.88 tons per year. So, that the estimated the level of utilization red snapper (*Lutjanus spp.*) in Archipelagic Fishing Port of Brondong is 75% with status of
utilization has been fully exploited. The allocation of fishing effort or use of capture equipment is equally important in controlling the ongoing fishing and management of fisheries ecosystem management [25].

4. Conclusion
Based on the results of research from the analysis of potential data and the status of utilization red snapper (Lutjanus spp.) caught by handline landed in Archipelagic Fishing Port of Brondong can be obtained the results of analysis of the potential of sustainable catch of red snapper in Archipelagic Fishing Port of Brondong obtained the value of maximum sustainable catch (Y_{MSY}) is 102.88 tons per year and the number of maximum sustainable effort (f_{MSY}) is 709 trips per year. The number of total allowable catch (Y_{TAC}) is 82.31 tons and the number of total allowable effort (f_{TAC}) is 242 trips per year. the level of utilization red snapper (Lutjanus spp.) caught by handline is 75%, where status of utilization red snapper (Lutjanus spp.) landed in Archipelagic Fishing Port of Brondong has been fully exploited.

References
[1] Wahyuningsih, Prihatiningsih, and Ernawati T 2013 Population parameters of red snapper (Lutjanus malabaricus) in eastern java sea BAWAL. 5 175–179
[2] Ernawati T & Sumiono B 2009 Monthly fluctuation of the danish seine catch in Tegal Sari landing based on Tegal City Fisheries Research Journal. 5
[3] Budiman Supriharyono and Asriyanto 2006 Distribution analysis of demersal fish in kendal – regency water as management basic of coastal resources Jurnal Perairan, 2 52–63
[4] Dafiq A H, Anna Z, Rizal A and Suryana A A H 2019 Analisis bioekonomi sumber daya ikan kakap merah (lutjanus malabaricus) di perairan kabupaten indramayu jawa barat Jurnal perikanan dan kelaatun. X 8–19.
[5] Krisnafi Y, Syamsudin S and Nugraha E 2018 Analysis of catch per unit effort red snapper resources in brondong archipelagic fishing port lamongan districk east java province indonesia The international journal of engineering and science. 7 52–57
[6] Melianawati R & Aryati R W 2012 Culture of emperor snapper Lutjanus sebae Journal of Tropical Marine Science and Technology. 4 80-88
[7] Santoso D 2016 Sustainable potential and utilization status of red snapper and grouper in the alas strait, west nusa tenggara province Journal of Tropical Biology. 16 15-24
[8] Shadiqin I, Yusfiandyani R, and Imron M 2018 Productivity of hand line on portable fad, in the water of north aceh district Journal of Fisheries and Marine Technology. 9 105-113
[9] Mous P J, Pet J S, Arifin Z, Djohani R, Erdmann M V, Halim A, Knight M, Pet-Soede L and Wiadnya G 2005 Policy needs to improve marine capture fisheries management and to define a role for marine protected areas in Indonesia Fisheries management and ecology. 12 259–268
[10] Swartz W, Sala E, Tracey S, Watson R and Pauly, D 2010 The spatial expansion and ecological footprint of fisheries (1950 to present) Global expansion of marine fisheries. 5 3–8.
[11] Branch T A, Jensen O. P, Ricard D, Ye Y and Hilborn R A Y 2011 Contrasting global trends in marine fishery status obtained from catches and from stock assessments Conservation biology. 25 777-86
[12] Jamal M, Sondita F A, Wiryyawan B and Haluan J 2014 management concept of skipjack tuna (katsuwonus pelamis) fisheries within bone bay zone in the perspective of sustainability Jurnal ipteks psp oktober. 1 196–207
[13] Libecap G D 2005 Handbook of New Institutional Economics, eds C Menard and M M Shirley (Netherlands: Spingers) p 545–546.
[14] Groeneveld J C 2003 African Journal of marine science. 25 407–411
[15] Pedersen M W and Berg C W 2017 A stochastic surplus production model in continuous time Fish and fisheries. 18 226–243
[16] Badrudin 2013 Analisis data catch & effort untuk pendugaan msy *Indonesia marine and climate support (imacs) project*

[17] Chassot E, Nishida T and Fonteneau A 2009 Application of surplus production models to the indian ocean bigeye (thunnus obesus) tuna fishery *Fisheries research*. 5–7.

[18] Okamura H, Morita S H, Funamoto T, Ichinokawa M and Eguchi S 2018 Target based catch-per-unit-effort standardization in multispecies fisheries *Canadian Journal of Fisheries and Aquatic Sciences*. 75 452–463.

[19] Gulland, J. A. (1983). *Fish Stock Assessment: a Manual of Basic Methods*. Chichester: John Wiley and Sons

[20] Skalski, J. R., Ryding, K. E., & Millspaugh, J. J. (2005). Estimating Population Abundance. *Wildlife Demography*. 435–539.

[21] Sparre P and Venema S C 1998 Introduction to tropical fish stock assessment part 1: Manual (Rome: FAO)

[22] Garcia S, Sparre P and Csirke J 1989 Estimating surplus production and maximum sustainable yield from biomass data when catch and effort time series are not available *Fisheries research*. 8 13–23

[23] Militz T A, Kinch J, Schoeman D S and Southgate P C 2018 Use of total allowable catch to regulate a selective marine aquarium fishery *Marine Policy*. 90 160–167

[24] FAO 1995 Code of conduct for responsible fisheries (Rome: FAO)

[25] Maunder M N 2002 The relationship between fishing methods, fisheries management and the estimation of maximum sustainable yield *Fish and Fisheries*. 3 251–260

**Acknowledgements**

This research is funded by Hibah Skema Publikasi Internasional Terindeks Mahasiswa Sosial Humaniora (PUTI SOSHUM) Universitas Indonesia (Contract Number NKB2553/UN2.RST/HKP.05.00/2020).