Potential, production and utilization level of pelagic fish resource in Ambon City

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Abstract. In responsible and sustainable fisheries, marine resources should be exploited at optimum level in which potency, production and utilization level is known. This research was conducted to analysed potency, production and utilization level of pelagic fish in Ambon Island waters. Data for the analysis was obtained from the secondary data of Dinas Kelautan dan Perikanan Maluku province in the form of catch and effort for period 2005 – 2015 and then analysed by using Schaefer model. Estimated Maximum Sustainable Yield (MSY) was 103,513 tons with Total Allowable Catch (TAC) was 82,811 tons. Production of pelagic fish fluctuated but tended to increase due to increasing of fishing vessels and fishing gears. Catch per unit effort of purse seine and pole and line contributed more for the pelagic fish production than five other fishing gears. The utilization of pelagic fish resources in Ambon tended to increase with annual average 61.7% from TAC or 49.40% of MSY during the period of 2005-2015. In the last three years (2013-2015) the level of utilization increased significantly and has reached 98.31% from TAC or 78.65% of MSY which leads to fully exploitation. These results indicated that fishing effort should be maintained and monitored strictly to prevent over exploitation of pelagic fish resource.

1. Introduction

The utilization of fishery resources will succeed if done at an optimum level because it will fulfill the current generation without reducing the satisfaction that the next generation. The utilization of fish resource through fishing activities optimally and profitably is expected in accordance with the principles of responsible and sustainable use of fish resources. At optimum level of exploitation, knowledge of the potential, production, and level of utilization of fish resources in the waters can be used to recommend the amount of fishing effort that may be carried out by capture fisheries in certain areas.

Pelagic fish is a type of fish that spends most of its life in the waters column which consist of large pelagic fish and small pelagic fish [1]. The fishers in Ambon City have been active in catching pelagic fish in the surrounding waters since a long time ago. Those pelagic fishes are caught by using various fishing gears namely hand line, troll line, pole and line, lift net, gill net, purse seine and beach seine.

Even though have been exploited for long time by fishers in the area, information on potency, production and the level of utilization of pelagic fish resource in Ambon Island waters is still lacking and currently not analyzed yet. A research is needed to express it, so that the management of pelagic fish resources in the waters of Ambon City can be carried out properly and appropriately. The purposes of this study were to analyse and determine the potential, production, and level of utilization of pelagic fish in Ambon City. The results of this study can become a database and information that can be used by all fisheries stakeholders to manage and utilize pelagic fish resources in the surrounding waters of Ambon City.
2. Materials and Method

2.1. Data collection
Information on operation and fishing activities of pelagic fish was collected directly through interviewed fishers in Ambon City at 16 locations. Secondary data of catch and effort was obtained from DKP Maluku Province [2] to analyses potential, production and level of utilization of pelagic fish.

2.2. Data analysis

2.2.1. Potential of pelagic fish resource. Potential and utilization of pelagic fisheries resources were analyzed by using surplus production model of Schaefer [3, 4, 5, 6, 7]. The application of this model needs time series data of catch and effort for several years. Since pelagic fish is caught by fishers in Ambon City by using seven fishing gears, standardization was made for all fishing gears through calculation of Fishing Power Index (FPI) in which the most productive gear is given the highest value of FPI=1.00, while less productive fishing gears were converted with their value of FPI<1.00 [3].

2.2.2. Production of pelagic fish. The production development ($P_p$) of small pelagic fish from 2005 to 2015 was calculated by using the periodic series method [8]:

$$P_p = \{(C_n+1 - C_n)/C_n\} \times 100\%$$

where: $C_{n+1}$ is total production of pelagic fish from Ambon City in the year $n+1$

$C_n$ is total production of pelagic fish from Ambon City in the year $n$

The results of this calculation were displayed in graphical form to show trajectory of the development of the annual production of pelagic fish. Trajectory explanation of pelagic fish production in the form of CPUE (catch per unit effort) contributed by each fishing gear were done through Multiple Interrupted Time Series Analysis (MITSA) model [9] with multiple regression applications [10, 11] uses a dummy variable [12]:

$$CPUE = a_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7$$

where: $a_0$ is the intercept

$b_1$ - $b_7$ is the function’s coefficient

$X_1 - X_7$ is a dummy variable

= 1 for CPUE of the concerned fishing gear

= 0 for CPUE of other fishing gear

Beach seine ($X_1$), purse seine ($X_2$), gill net ($X_3$), lift net ($X_4$), pole and line ($X_5$), trolling ($X_6$), and hand line ($X_7$). The hypothesis applied is:

$H_0 : \beta (b_1 - b_7) = 0$, there is no relationship between X and Y

$H_1 : \beta (b_1 - b_7) \neq 0$, there is a relationship between X and Y

The F test results "at the significance level of 5% (0.05), if the probability (P) <0.05, it can be said that there is a significant joint effect between each type of fishing on CPUE from 2005 to 2015.

2.2.3. Utilization level of pelagic fish resources. The level of utilization of fish resources in the Ambon City fishing ground was calculated based on the percentage (%) of annual fish production (tons) per estimated of pelagic fish resource potential or MSY (maximum sustainable yield) [5]:

$$E_i = (C_i/MSY) \times 100\% \text{ and/or } E_i = (C_i/TAC) \times 100\%$$

where: $E_i$: Level of utilization of pelagic fish resources in Ambon City in the year $i$

$C_i$: Catch (production) of pelagic fish in the year $i$
3. Results and Discussion

3.1. Potential of pelagic fish resources in Ambon City

Fishing operations are carried out in fishing grounds in the waters of Ambon City and its surroundings including the Banda Sea. Pelagic fish resources that are captured by fishers in Ambon City consist of large pelagic and small pelagic fish. Small pelagic fish species that dominantly captured are scad (Decapetus spp), selar (Selar spp), mackerell (Rastrelliger spp), cardinalfish (Cypisilurus spp), sardines (Sardinella spp), and anchovies (Stolephorus spp), whereas the most dominant large pelagic fish caught are mackarel tuna (Auxis thazard; Euthynnus affinis), skipjack (Katsuwonus pelamis), and yellowfin tuna (Thunnus albacares).

Since the species listed above are caught by seven fishing gears, standard fishing gears should be made done through fishing power index (FPI) to get standard effort and catch per unit effort (CPUE) (Table 1).

| Year | Beach Seine | Purse Seine | Gill Net | Lift Net | Pole &Line | Troll Line | Hand Line | FPI For Each Type of Fishing Gear | Standard Effort (trip) | CPUE (ton/trip) |
|------|-------------|-------------|---------|----------|------------|------------|-----------|---------------------------------|----------------------|----------------|
| 2005 | 0.00458     | 0.21250     | 1.00000 | 0.00125  | 0.09664    | 0.00579    | 0.00002   | 521                             | 39.70                |
| 2006 | 0.00474     | 0.40344     | 0.02752 | 0.00109  | 1.00000    | 0.01787    | 0.00005   | 1186                            | 24.67                |
| 2007 | 0.00927     | 1.00000     | 0.05337 | 0.00233  | 0.41384    | 0.07329    | 0.00058   | 1611                            | 18.56                |
| 2008 | 0.00877     | 1.00000     | 0.07118 | 0.00232  | 0.47682    | 0.10836    | 0.00084   | 2003                            | 15.82                |
| 2009 | 0.02967     | 0.36008     | 0.03962 | 0.00293  | 0.99999    | 0.04773    | 0.00325   | 9480                            | 4.83                 |
| 2010 | 0.00579     | 0.22811     | 0.01981 | 0.00233  | 1.00000    | 0.01655    | 0.00054   | 2861                            | 19.70                |
| 2011 | 0.00292     | 0.08153     | 0.00728 | 0.00056  | 1.00000    | 0.02179    | 0.00145   | 959                             | 53.11                |
| 2012 | 0.01088     | 0.30068     | 0.14194 | 0.00350  | 1.00000    | 0.03441    | 0.05429   | 3828                            | 13.76                |
| 2013 | 0.02030     | 0.79832     | 0.17746 | 0.00801  | 1.00000    | 0.06451    | 0.00218   | 9215                            | 9.24                 |
| 2014 | 0.02114     | 0.50436     | 0.16472 | 0.00727  | 1.00000    | 0.06069    | 0.29610   | 1186                            | 6.54                 |
| 2015 | 0.02448     | 0.61627     | 0.19860 | 0.00647  | 1.00000    | 0.04901    | 0.21036   | 13322                           | 6.61                 |

Source: Processed from the Maluku Province Marine and Fisheries Service (2006-2016)

The linear relationship of the Schaefer model between effort \( f = \text{trip} \) with CPUE is shown in Figure 1 with the equation \( y = -0.0024x + 31.529 \) (\( r=0.9118 \)) or CPUE = 31.529 – 0.0024f. The value of correlation coefficient, \( r = 0.9118 \) indicated that there is a significant relationship between effort and CPUE and this relationship can be used for further analysis. Contribution of effort to CPUE which is showed by coefficient of determination \( (R^2) = 0.8314 \) indicated that 83.14\% variation in CPUE can be explained by effort and 16.86\% is explained by other factors. The negative value of regression coefficient \( b \) (slope) suggested that increasing of effort \( f=\text{trip} \) will cause decreasing of CPUE.

Based on the linear relationship of the Schaefer model, estimated maximum sustainable yield, MSY is 103,513 tons/year and the number of effort to achieve this MSY, \( f_{\text{opt}} \) is 6,566 trips/year (Figure 2). Fishing ground of Ambon fishers to catch pelagic fish including Banda Sea. Banda Sea is one of Fisheries Management Areas of the Republic of Indonesia (WPP) i.e. WPP 714 with estimated pelagic fish potential in WPP 714 is 159,578 tons/year [13]. Thus, it can be said that the potential of pelagic fish resources in the fishing ground of Ambon City is 64.87\% of the potential of fish resources established by the Government of the Republic of Indonesia in WPP 714.
3.2. Production of pelagic fish in Ambon City

Fish production from fishing activities is at least determined by the ability of fishermen to reach fishing grounds using fishing vessels. The development of fishing vessels used by fishers in Ambon City from 2005 to 2015 is presented in Figure 3. It turned out that the trajectory of the number of fishing vessels used by the fishers of Ambon City tended to increase or increase in number over the past 11 years (Figure 3A), although the percentage (%) the use of outboard motors tends to decrease (Figure 3B). This condition indicates that there has been a positive development in technology and
fishing activities in Ambon City in fishing operations to access the fishing ground further in the surrounding waters.

The use of fishing vessels based on driving force from 2005 to 2015 is still dominated by boats without engines (not using engines as driving force). The development of the use of fishing vessel's driving force every year by the fishermen of Ambon City, namely those with outboard engines as much as 23.4% to 31.9% and those that use internal engines (motorboats) are only 3.1% to 5% of all ships/motorized boats in Ambon City. This condition indicated that their ability to access further fishing ground is still limited. Nevertheless, fishers who use motorized boats that catch large pelagic fish by pole and line and outboard motor boats to operate troll line are able to access fishing grounds in the Banda Sea and Seram Sea.

**Figure 3.** Trajectory of the number (A) and percentage (B) of fishing vessel/boat based on the driving force in Ambon City in 2005-2015

The use of fishing vessels/boats that are able to reach waters further in the shortest possible time, greatly determines the number and quality of fish caught. Fishing vessels that are used to operate fishing gears, must be seaworthy and able to fishing-gear-used operate. The size of the ship in the form of gross tonnage (GT) used by the fishermen of Ambon City can explain the production capacity that can be produced. The size of pelagic fishing vessels is shown in Table 2.

**Table 2.** Gross tonnage (GT) and the ratio of the main dimensions of 7 (seven) types of pelagic fishing vessels in Ambon City

| No. | Fishing Vessels/Boats       | Number of Units | Gross Tonnage (GT) |         |         |         |
|-----|-----------------------------|-----------------|--------------------|---------|---------|---------|
|     |                             | Minimum | Maximum | Average |
| 1.  | Beach Seiner                | 6       | 0.59    | 2.10    | 1.09    |
| 2.  | Purse Seiner                | 44      | 7.88    | 25.27   | 14.92   |
| 3.  | Gill Netter                 | 44      | 0.13    | 1.84    | 0.61    |
| 4.  | Lift Netter                 | 6       | 0.95    | 1.54    | 1.24    |
| 5.  | Pole And Liner              | 6       | 17.74   | 30.24   | 22.94   |
| 6.  | Troll Liner                 | 35      | 0.15    | 1.91    | 0.73    |
| 7.  | Hand Liner                  | 29      | 0.03    | 0.25    | 0.13    |

All types of fishing vessels are used to operate the fishing gears, except lift nets that are used as transport vessels. Table 2 above shows that in general pelagic fishing vessels used by Ambon City fishers ≤ 5GT which are intended to operate on the “Ia” fishing trajectory (in the area of 0-2 nautical miles from the lowest ebb), but fishing vessels that operate troll line often access up to the "II" catchment trajectory (area 4-12 nautical miles from the lowest ebb) and "III" (area >12 nautical miles from the lowest ebb). The purse seiner and the pole and liner that are used have an average size ≥ 10
GT, which according to the regulations is permitted to operate on the "II" and "III" catchment trajectory.

The Ambon City fishermen’s activity in catching pelagic fish use 7 (seven) types of fishing gear, namely beach seine, purse seine, gill nets, lift nets, pole and line, troll line, and hand line. The dominant number of pelagic fishing gears used is hand line and gill net and tends to increase during 2005 to 2015, in addition to beach seines and lift nets (Figure 4A). However, the percentage (%) of using hand lines tends to decrease (Figure 4B).

Source: Processed from Maluku Province Marine and Fisheries Service (2006 - 2016)

Figure 4. Trajectory of the number (A) and percentage (B) of 7 (seven) types of pelagic fishing gears in Ambon City in 2005-2015

Hand line operations in Ambon City fishing grounds tend to decrease compared to other types of fishing gear to catch pelagic fish, indicating a change in the use of better pelagic fishing gears, because hand line is known as a very traditional fishing gear and found in many artisanal capture fisheries.

Pelagic fish production from this fishing activity shows dynamic fluctuations according to the time and location of fishing during 2005 to 2015. However, the production trajectory shows a tendency to increase because the application of pelagic fishing technology by the fishermen of Ambon City has improved as shown in Figure 5A and Figure 5B.

Source: Processed from Maluku Province Marine and Fisheries Service (2006 - 2016)

Figure 5. Production trajectory (A) and percentage (%) of the development of pelagic fish production (B) in Ambon City in 2005-201
Percentage (%) of the fluctuating development of pelagic fish production for 11 (eleven) years mentioned above, 3 (three) times down and 3 (three) times up. Pelagic fish production declined in 2006 to 2007, 2009 to 2011, and 2013 to 2014. Production of pelagic fish tend to increase in 2007 to 2009, 2011 to 2013, and in 2014 to 2015. Conditions the development of pelagic fish production if it is analyzed for its suitability with the use of fishing vessels and pelagic fishing gears by the fishermen of Ambon City, it turns out that the patterns are not the same in those years. Thus, the development of pelagic fish production is also influenced by other factors of fishing technology besides fishing vessels and fishing gears, for example the application of fishing methods, fishing season, fishing skills, and so on.

Multiple regression analysis of fishing gear production capabilities in the form of CPUE for each type of pelagic fishing gear in Ambon City from 2005 to 2015 as follows:

$$CPUE = 0.44 - 0.29X_1 + 7.03X_2 + 4.05X_3 - 0.40X_4 + 13.87X_5 + 0.21X_6$$

The F test produces a probability value, $P = 0.00 < 0.05$, explaining that the use of the regression equation is relatively satisfactory and it can explain the annual CPUE data for each type of fishing gear. The results of various regression tests proved that purse seine and pole and line CPUE contributed more significantly to pelagic fish production from 2005 to 2015, compared to other types of fishing gears. This condition is possible because the inability to access further fishing ground.

3.3. Utilization level of pelagic fish resources in Ambon City

Pelagic fishing efforts have had an impact on pelagic fish production which tends to increase from 2005 to 2015 with the average annual pelagic fish production is 51,042 tons/year (49.4% of MSY or 61.7% of TAC), thus utilization level (E) is still below TAC and MSY i.e. 82,811 and 103,513 tons/year, respectively (Figure 6). However, in the last 3 year in 2013-2015 the average pelagic fish production increased to 81,409 tons/year or 98.31% of TAC and 78.65% of MSY, even in the year 2013 the production was 85,200 tons or E is still below MSY (82.31%) but far above TAC (102.9% of TAC). The level of utilization of pelagic fish resource in this study is similar to level of utilization stated by Government of the Republic of Indonesia for pelagic fish in Banda Sea (WPP 714) i.e. 78% of MSY.

![Figure 6. Production status and level of utilization of Pelagic fish in Ambon City from 2005-2015 to MSY and TAC](image)

There are three criteria for E of fishery resources i.e. moderate (E<0.5), fully-exploited (0.5 ≥ E <1) and over-exploited (E ≥ 1) [13]. Based on those criteria, average E for the year 2005 to 2015 can be categorized as moderate, however for the last 3 year (2013 – 2015) E is fully-exploited. This figure suggests that fishing effort to exploit pelagic fish in the area should be maintained with a strict monitor.
4. Conclusion
This study concludes several things according to its objectives, as follows:

1) Potential resources of pelagic fish in the waters of Ambon City and its surroundings, namely Maximum Sustainable Yield (MSY) is 103,513 tons / year with total allowable catch (TAC) is 82,811 tons / year.

2) The actual production of pelagic fish in Ambon City from 2005 to 2015 although fluctuating but tended to increase, even on average in the last three years increased significantly because the use of fishing vessels and fishing gears also increased. CPUE of purse seine and pole and line contribute to pelagic fish production than other fishing gears.

3) The level of utilization of pelagic fish resources in Ambon City tends to increase from 2005 to 2015 and on average is 61.7% of TAC or 49.40% of MSY, but in the last three years it has reached 98.31% of TAC or 78.65% of MSY (fully-exploited). In general, the utilization rate is still below MSY and TAC, except in 2013 although it is still below MSY but has exceeded TAC.

Data and information about the potential, production, and utilization of fish resources in the waters of Ambon City must always be known so that it is necessary to conduct similar research on various available fish resources.

Acknowledgement
The authors express our deep gratitude to the enumerators and a brother, W. Waileruny, who joyfully helped the implementation of this research.

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