Population structure of Indian scad fish (*Decapterus russelli*) that was landed at the Nusantara Fishing Port of Ternate, North Maluku, Indonesia

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Abstract. Indian scad fish (*Decapterus russelli*) is a small pelagic fish species commonly caught in Indonesian seas. Excessive fishing efforts can cause population degradation, so it is necessary to understand its population structure. The purpose of this study was to analyze the population structure parameters of Indian scad fish, including growth parameters, cohort, and mortality. Sampling was done by Stratified Random Sampling method. Data analysis used the FISAT II application. Study results showed that there were 4 cohorts. The growth parameters of Indian scad fish obtained asymptote length (*L∞*) of 296.15 mm, coefficient of growth rate (*K*) of 0.60 per year, and initial age (*t0*) of -0.66 years. Value of coefficient of growth rate (*K*) indicated that growth of scad was relatively slow. The total mortality value (*Z*) was 0.51 per year, natural mortality (*M*) was 0.0034 per year, and fishing mortality (*F*) was 0.51 per year. So that the highest Indian scad fish mortality was caused by fishing mortality. The exploitation rate (*E*) was 1 per year, indicating that the Indian scad fish resources have been overexploited.

1. Introduction

Indian scad fish is a small pelagic fish species that is commonly caught in Indonesian seas [1]. Swallow fish have a habit of living in groups with other small pelagic fish. Flying fish are spread in the waters of the Java Sea, Makassar, Ambon, Ternate, and Eastern Indonesia [2]. The Indian scad fish (*Decapterus russelli*) plays an important role in improving the economy of fishermen in North Maluku. Data on production of various pelagic fish from 2 types of fishing gears, namely purse seines and gill nets in 2019 was 1,570.28 tons with a production value of Rp 18,519,166,000.

Indian scad fish is a popular fishing target since it has good economic value. This triggers the exploitation of these resources. Although Indian scad fish is also a renewable resource, the rate of recovery is not balanced with the rate of utilization. If fishing efforts are carried out continuously without responsible management, it can lead to population degradation [3].

The fishing effort of Indian scad fish can cause population degradation and economic value. Therefore, it needs to be supported by various sources of knowledge about fish population structure [4]. Fish population structure is one of the strategies in predicting population conditions in water areas.
Fish population structure such as cohort, growth, and mortality. It aims to utilize fish resources in the waters responsibly [5]. The purpose of this study was to analyze the parameters of the population structure of *Decapterus russelli* landed at the Nusantara Fisheries Port (PPN) of Ternate City in the form of growth parameters, cohort, and mortality.

2. **Material and method**

This research was conducted from September to December 2020 at Nusantara Fisheries Port (PPN) of Ternate, North Maluku. Sampling was carried out using the Stratified Random Sampling method, namely random sampling based on differences in size of fish landed at the Nusantara Fisheries Port (PPN) of Ternate. A sampling of Indian scad fish was taken every month as many as 8 times with a total of 485 sample fish. For each sample fish, its total length was measured using a ruler. The total length of a fish was measured from the tip of the mouth to the tail end. All measurement data was then recorded on worksheet provided.

Results of total length measurement are then analyzed for frequency distribution, namely sorting data from smallest to largest, sorting range, determining number of classes (*K*) with the Sturges formula:

\[
K = 1 + 3.3 \log N
\]  

(1)

Where *K* is the number of classes, *N* is the total amount of data. Determine the length of the class interval (*i*) with the formula:

\[
i = \frac{R}{K}
\]  

(2)

Where *i* is class interval, *R* is a range, *K* is the number of classes. Growth can be estimated by using the Von Bertalanffy growth formula [6]:

\[
L_t = L_\infty \left[ 1 - e^{-k(t+t_0)} \right]
\]  

(3)

\[
L_\infty = \frac{a}{1-b}
\]  

(4)

\[
k = -\ln b
\]  

(5)

Where *L*\(_t\) is the Length of fish at a certain age, *L*\(_\infty\) is asymptote length (mm), *k* is the coefficient of growth rate, *t*\(_0\) is the theoretical age of fish at length equal to zero. Then to determine *t*\(_0\) used [7] formula:

\[
\log (-t_0) = -0.3922 - 0.275 \log L_\infty - 1.038 \log k
\]  

(6)

Cohorts were estimated using data on the frequency of the total length of fish by separating the number of distributions of total length classes, thus forming each cohort. Minimum fish age of 3 cohorts was used to analyze other growth parameters. Mean value for each length class as the X-axis was plotted along with the difference in the logarithm of the frequency of the long class as the Y-axis. At the plotted points, it would form a straight line and produced a value (the average length of fish for each age group). Then the value was calculated with following equation:

\[
\bar{x} = -\frac{a}{b}
\]  

(7)

Where \(\bar{x}\) is average value, *a* is the intercept, *b* is a slope.
Mortality data consisted of total mortality, natural mortality, and fishing mortality. To calculate total mortality, it can be estimated using the following Beverton and Holt equation [6]:

$$ Z = K \frac{L_\infty - L}{L - L'} $$  

(8)

Where $Z$ is total mortality rate (per year), $K$ is coefficient of growth rate (per year), $L_\infty$ is asymptote length (mm), $L$ is the average length of fish (mm), $L'$ is the smallest fish size (mm). The natural mortality rate was estimated using [7] empirical formula as follows:

$$ \log(M) = -0.0066 - 0.279 \log(L_\infty) + 0.6543 \log(K) + 0.5634 \log(T) $$  

(9)

Where $M$ is natural mortality (per year), $L_\infty$ is asymptote length (mm), $K$ is coefficient of growth rate (per year), $T$ is average water surface temperature ($^\circ$C). Fishing mortality ($F$) was estimated using [7] empirical formula as follows:

$$ F = Z - M $$  

(10)

Exploitation rate is the number of fish caught compared to the total number of fish that die due to natural factors and fishing factors. Therefore, the formula for estimating the rate of exploitation ($E$) is as follows [7]:

$$ E = \frac{F}{Z} $$  

(11)

Where $F$ is fishing mortality rate, $Z$ is the total mortality rate, $M$ is the natural mortality rate, $E$ is exploitation rate. Category; if $E > 0.5$ then the exploitation rate is high, if $E = 0.5$ then Optimal exploitation rate, if $E = 0.5$ then low exploitation rate.

3. Result

Results of total length measurement of Indian scad fish in September ranged from 184 to 295 mm. Class that had the largest frequency was 212-225 mm length group consisted of 8 fish (Figure 1a). Total length in October ranged from 184 to 295 mm. The class that had the largest frequency was 240-253 mm and 254-267 mm group consisted of 24 fish and class that had the smallest frequency was 198-211 mm group with 5 fish (Figure 1b). Total length in November ranged from 179 to 295 mm. Class that had the largest frequency was 269-283 mm group consisting of 20 fish and class that had the smallest frequency was 194-208 mm group consisting of 10 fish (Figure 1c). Total length in December ranged from 181 to 294 mm. Class that had the largest frequency was 237-250 mm length group with 24 fish and class that has the smallest frequency was 293-306 mm group consisting of 3 individuals (Figure 1d).

Data analysis results showed that there were 4 cohorts in sample fish. The first cohort (September) had an average length of 195.56 mm, the second cohort (October) had an average length of 242.75 mm, the third cohort (November) with an average length of 258.35 mm, and the fourth cohort (December) had an average length of 281.58 mm (Figure 2).

Estimated results of fish growth parameters showed that the maximum length of Indian scad fish during its lifetime ($L_\infty$) was 296.15 mm, the coefficient of the growth rate of the Indian scad fish ($K$) was 0.60 per year, and the initial age (to) was -0.66 year. Thus, the equation for the growth of Indian scad fish of the study could be obtained using the Von Bertalanffy equation as follows:

$$ L_t = 296.15 \left(1 - \exp^{-0.60(t+0.66)}\right) $$  

(Figure 3).
Figure 1. Size distribution of the Indian scad fish

Figure 2. Cohort distribution of the Indian scad fish

Figure 3. Relationship between total length and age of Indian scad fish

Based on above estimation results, calculated total mortality value (Z) was 0.51 per year. The Z value was obtained from natural mortality (M) and fishing mortality (F). The exploitation rate


(E) was obtained from comparison between the values of F and Z. The value of E is 1 per year (Table 1).

| Population Parameters | Estimated value (per years) |
|-----------------------|----------------------------|
| Total Mortality (Z)   | 0.51                       |
| Natural Mortality (M) | 0.0034                     |
| Fishing Mortality (F) | 0.51                       |
| Exploitation rate (E) | 1                          |

4. Discussion

Based on total length data of the Indian scad fish in September-December, total length range found was 179 to 296 mm. Value of the total length range in this study was relatively larger than total length of Indian scad fish caught in Malacca Strait ranging from 99 to 224 mm [8] and the range of total length of Indian scad fish caught in Luwu Regency Sea, namely 90-290 mm [9].

Figure 2 shows that from September-December there was only one cohort with a larger shift in length. The larger the size of the fish, the less fish population in the waters. This was due to oceanographic conditions, mortality, and the rate of recruitment [10].

The asymptote length (L∞) means that the maximum length of the Indian scad fish is 296.15 mm. Compared with previous studies, it was shown that the maximum length in North Maluku waters was 300 mm [11]. This indicated that the maximum length in Ternate waters was decreasing. The shorter the maximum length (L∞) indicated that there had been a high intensity of fishing for Indian scad fish so that its population size was getting smaller [12].

The value of coefficient of growth rate (K) of less than one indicated that the growth of Indian scad fish was relatively slow. The lower the growth rate, the longer it takes for the Indian scad fish to reach its maximum length [6]. It is also influenced by heredity, sexuality, age, disease, parasites, food and water conditions [13]. The value of t0 indicates the age of the fish at hatching [6].

Figure 3 shows that the Indian scad fish experience very fast growth at the age of 1-9 years. Meanwhile, at the age of 10-29 years, the Indian scad fish has experienced very slow growth until the total length reaches 296.15 mm. Swallow fish at a young age experience rapid growth in length. Meanwhile, along with increasing age, the length growth of Indian scad fish is getting slower until it reaches its maximum total length [5]. In general, fish that experience a lack of food causes stunted fish growth. This is due to the movement of fish that utilize more of the food they contain.

The study found that value of fishing mortality (F) was greater than natural mortality (M). This showed that dominant fishing factor caused the death of Indian scad fish. Low natural mortality rate and high fishing mortality rate indicated that overfishing had occurred, namely that more young fish were caught than older fish [6].

The optimum exploitation rate for a resource was 0.5 per year [14], so it was assumed that the Indian scad fish resources were in high exploitation category (overexploitation). In general, high number of fishing gear and fishing intensity can affect the rate of fish exploitation [15]. Besides, adult fish that are caught before spawning at least once in their life cycle will have an impact on the degradation of fish stocks, resulting in no addition of new individuals to the stock, and eventually, the Indian scad fish population will decline [16].

5. Conclusion

The cohort of the Indian scad fish population consisted of 4 cohorts during September - December. The growth rate was relatively slow. Mortality of Indian scad fish was mainly resulted from fishing factors. And the rate of exploitation of Indian scad fish resources has been over-exploited.
References

[1] Prihatini A, Anggoro S, Asriyanto 2006 Analysis of the biological appearance of Indian scad fish (Decapterus sp) captured purse seine landed at PPN Pekalongan. *Sea Sand*. 3 61-75.

[2] Safruddin 2013 The distribution of Indian scad fish (Decapterus sp) is related to oceanographic conditions in the waters of Pangkep Regency, South Sulawesi. *Torani (Journal of Marine and Fishery Sciences)*. 23 150-156.

[3] Irham 2009 Patterns of sustainable development of Indian scad fish (Decapterus russelli) resources in North Maluku waters. [Dissertation]. Bogor Agricultural University. Indonesian. 174 p.

[4] Sururi M, Mustasim, Franklyn H, Anasri 2017 The exploitation rate of Indian scad fish resources (Decapterus macrosoma) landed at the Fish Landing Base (PPI) Sorong city, West Papua. *Airaha Journal*. 6 001-009.

[5] Sari H 2013 Estimation of several parameters of population dynamics of Indian scad fish (Decapterus macrosoma) in Bone Bay waters, South Sulawesi. [Essay]. Hasanuddin University. Makassar. Indonesian. 438 p.

[6] Sparre P and Venema S C 1999 Introduction to the study of tropical fish stocks (Translated Edition). Cooperation of the Food Organization, United Nations with Fisheries Research and Development Center, Agricultural Research and Development Agency. Jakarta. Indonesian. 438 p.

[7] Pauly D 1984 *Fish population dynamics in tropical waters: a manual for use with programmable calculators*. ICLARM: Filipina. 325 p.

[8] Alnanda R, Isdradjad S, Mennofatria B 2020 Population dynamics of Indian scad fish (Decapterus russelli) in the waters of the Malacca Strait. *Manfish Journal*. 1 1-8.

[9] Rosmini 2008 Exploitation levels and population dynamics of Indian scad fish (Decapterus sp) around the waters of Luwu regency. [Essay]. Hasanuddin University. Makassar. Indonesian. 57 p.

[10] Rudianto D 2017 Population dynamics of albakora tuna (Thunnus alalunga Bonnaterre, 1788) landed at Prigi Fishery Port (PPN) Trenggalek regency, East Java. [Essay]. Brawijaya University. Malang. Indonesia. 123 p.

[11] Manik N 2003 Several population parameters of Indian scad fish (Decapterus russelli) in North Maluku waters. *Indonesian Oceanology and Limnology*. 35 21-36.

[12] Wudji A, and Suwarso W 2013 Reproductive biology and spawning season of lemuru fish (Sardinella lemuru Bleeker 1853) in the waters of the Bali Strait. *Bawai (Widya Capture Fisheries Research)*. 5 49-57.

[13] Effendi 2002 Fisheries Biology. *Nusantara Library Foundation*. Yogyakarta. 163 p.

[14] Gulland J A 1983 *Fish Stock Assesment: A Manual of Basic Methods*. New York. John Wiley and Sons. Inc.

[15] Suwarso, Fauzi M, Zamroni M, Kuswoyo A, Yahya F 2015 Status of utilization of small pelagic fish resources in Malacca strait waters. *Ref Graphics*. 4 30-59.

[16] King M 2007 *Fisheries biology, Assessment, and Management*. Fishing News Books. London, USA. 341p.