The Growth and Mortality Rate of Mullet (*Mugil dussumieri*) on Seagrass Beds of The Teluk Awur Bay, Jepara

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**Abstract.** Seagrass beds that have relatively high primary productivity are used as habitat for many marine species. Fish use seagrass as feeding, nursery, and spawning grounds. This research aimed to determinate the growth and mortality rates of mullet (*Mugil dussumieri*) on seagrass bed ecosystems of Teluk Awur Bay water, Jepara, Central Java. The descriptive method was applied in this research with the purposive method for sampling. Microsoft Excel software and FISAT II of FAO were used for data analyses, and the samples of 347 mullet (*M. dussumieri*) were taken from October until December 2016. The results of this research showed that length of fish ranges 8 – 28.9 cm with weight range 5 – 248 grams. The growth coefficient value (K) was 0.33 with asymptotic length (L∞) 30.24 cm, and the value of t₀ was -0.305, which will be reaching for 11 years. The rate of total mortality (Z) was 0.854 per year, the value of natural mortality (M) was 0.706 per year and the value of fishing mortality (F) was 0.148 per year. Exploitation ratio (E) was 0.173 per year, it indicated that only 17.3% of mullet’s (*M. dussumieri*) deaths in Teluk Awur Bay waters caused bycatch. It can be estimated that the death of mullet in Teluk Awur Bay waters affected more by the condition of the waters, in this case, the decreasing density of seagrass in research location is expected to affect the growth of mullet.

**Keywords:** Seagrass, Mullet (*Mugil dussumieri*), Growth, Mortality, Exploitation

1. **Introduction**
Seagrass beds is one of the most productive biomass and there is some function that seagrass can provide for biotas who lived in it, such as provide foods in coastal food webs, an organic carbon export to adjacent ecosystems, and habitat for invertebrates and vertebrates. Especially for fishes, including those in commercial fisheries, seagrass beds play several roles like nursery for juveniles, shelter, or feeding grounds [1].

The importance of seagrass bed as a habitat and food source for marine animals is expected to vary with the species composition of seagrass. Some researchers found the differences in fish assemblages in seagrass bed represented by different species of seagrass. The richness of seagrass species may influence faunal assemblages because more diverse seagrass provide greater structural complexity and therefore more niches for the associated plants and animals. The physical nature of the seagrass canopy is thought to play a major role, potentially influencing available shelter, food, and protection from predators. This fact is raising a concern about the role of seagrass diversity on their ecological function in marine ecosystems, in particular, because there is a tendency of declining and/or extinction of certain species of seagrass due to climate change and other factors [2].
In fishing and aquaculture, mullets are important economic resources that support many small communities. Mullets live as semi-catadromous, which the juveniles being recruited to lagoons and estuaries following a period of offshore spawning [3]. Previous research said that Mugilids are generally considered as herbivorous, omnivorous, plankton feeders, or even microcrustacean predators. The trophic behavior of mullets has been expressed by different authors using extensive terminology which categorized feeding patterns of these species. It includes algae feeders, micro and meioobenthos feeders, interface-feeders, deposit feeders, benthic microphagous omnivores and limnobenthofagous [4].

During the last decades, the problems of seagrass degradation have received increased attention worldwide. Seagrass loss, however, mainly occurs due to human impacts and the most eutrophication, this also may affect the density and composition of associated fish species [5].

The waters of Teluk Awur Bay, Jepara has a relatively fertile seagrass communities. The condition of coastal morphology will affect the density and the type of seagrass contained therein. However, the existence of human activities and fishing around the waters of Teluk Awur Bay allegedly may affect the density of the seagrass and the growth of fish in these waters. According to the Ministry of Marine Affairs and Fisheries in 2011 informed that there has been an increase in the number of catching mullets every year ranged from 2.4% from 36.077 tons in 2000 to 44.905 tons in 2010 [6].

Based on that conditions it is necessary to do research that aims to determine the rate of growth and mortality of mullet fish (Mugil dussumieri) which lives on seagrass in the waters of Teluk Awur Bay, Jepara. Existing data are expected to be useful and serve as basic data for the management of capture fisheries and seagrass ecosystems in Teluk Awur Bay waters, Jepara.

2. Materials and Methods

2.1. Time and Place

This research used mullet (M. dussumieri) as main material and descriptive method. This research was conducted in October - December 2016. Purposive sampling method was used to determine the sampling location, in this case, consideration of research location based on seagrass density conditions. Sampling was carried out in the waters of Teluk Awur Bay, Jepara for 10 hours from 06.00 a.m. – 16.00 p.m., followed the activities of fishermen.

Primary data was collected for three months with a two-week sampling time interval. Mullet fishing grounds located at coordinate 6°37’13.3” S dan 110°38’12.6” E. Fishing location is directly near to Marine Station, Teluk Awur Village, Jepara, Java Sea.

2.2. Sampling Method

Shore operated stationary lift nets that are settled in the waters was used to collect the fish data in this research. Lift nets frame mounted at a height of 8 meters above sea level, it had a net with overall width size is 6x6 meters and the mesh size is 1 cm. All the caught fish were taken to the mainland to be separated between mullets and other types of fishes. All of the fresh mullets were put into a cool box, and then it brought to the Diponegoro University Biology’s laboratory for the fish identification and the measurement of weight and length. The fish identification based on Saanin’s book (1968). Observation of water quality parameters measured in-situ together with mullets and seagrass sampling. The observed parameters are including temperature, dissolved oxygen (DO), salinity, pH, depth, and brightness.

2.3. Growth Parameter Analysis

The measurement of the total length of fish used a ruler with 0.1 cm accuracy, while the measurement of fish weight used a digital scales with 0.01 grams accuracy.

Data processing of distribution frequency in this research used Microsoft Excel software. The long fish-based growth model formula was exposed by Von Bertalanffy, and known as Von Bertalanffy's Model is [7]:

\[ L_t = L_\infty (1-\exp(-K(t-t_0))) \]
Where \( L_\infty \) is the mean length the fish would reach if they were to grow to a very old age (asymptotic length) (cm), \( K \) is a growth coefficient (cm), \( t_0 \) is an imaginary age of fish when they had zero length, and \( L_t \) is the length at the age \( t \).

The value for \( L_\infty \) and \( K \) were obtained from the calculation results by ELEFAN I method contained in the program FISAT II, meanwhile to get the value of \( t_0 \) can use von bertalanffy's empirical formula [8]:

\[
\log (-t_0) = 0.3922 - 0.2752 (\log L_\infty) - 1.0380 (\log K)
\]

2.4. Fish Mortality Analysis

The rate of total mortality \( (Z) \) based on Beverton and Holt [6] defined as:

\[
Z = \frac{K (L_\infty - L)}{L - L'}
\]

Where \( L_\infty \) and \( K \) are parameters of von Bertalanffy growth equations, \( L \) is mean length of fish in the catch (cm), and \( L' \) is the smallest length of fish in the catch (cm).

The calculation of the natural mortality value \( (M) \) is known through the empirical formula by Pauly and the calculation of fish habits that clustered in the value of natural mortality multiplied by the number 0.8. So that species are clustered have estimated value 20% lower [8]:

\[
\ln M = -0.0152 - 0.279 \ln L_\infty + 0.6543 \ln K + 0.463 \ln T \\
M = 0.8^* \exp(\ln M)
\]

Where \( L_\infty \) and \( K \) are parameters of von Bertalanffy growth equations and \( T \) is mean temperature (°C) of the water in which fish lives.

Total mortality value \( (Z) \) is the sum of the natural mortality value \( (M) \) and fishing mortality value \( (F) \), so that \( F \) is obtained from the following calculation results:

\[
F = Z - M
\]

If the fishing mortality \( (F) \) and natural mortality \( (M) \) has been obtained, so exploitation ratio \( (E) \) of fish may be computed from [8]:

\[
E = \frac{F}{F + M}
\]

3. Result and Discussion

3.1. Description of Condition of Research Sites

The caught fish on seagrass beds in Teluk Awur Bay mostly was the fish that are not the permanent inhabitant, even there were also fish that come from the coral reef. Types of fish that are often caught by fishermen in the form of mullets (\( Mugil \) sp.), ‘lencam’ fish (\( Lethrinus obsoletus \)), ‘baronang’ fish (\( Siganus oramin \)), and \( Lutjanus lutjanus \). However, the most commonly found fish with high economic value is mullets (\( Mugil \) sp.). Beside \( Mugil dussumieri \) as mullet species which was analyzed in this research, fishing gear also caught other types of mullets, such as \( M. subviridis \), \( M. tade \), \( M. troscheli \), \( M. seheli \), dan \( M. vaigiensis \).

Based on the previous study, it was known that \( M. dussumieri \) was a dominant mullet species in some waters of Indonesia and the larvae were found in coastal water near river estuaries. It was suitable with the Teluk Awur Bay conditions, where there were seagrass and mangrove ecosystems in the coastal waters which can be used as a place of life for mullet (\( M. dussumieri \)).

3.2. Seagrass Condition

Based on this research for seagrass density in the sites (\textbf{Table 1}), there were three species of seagrass that had been found, i.e. \( Enhalus acoroides \), \( Thalassia hemprichii \), and \( Cymodocea serrulata \). The most common type of seagrass was \( T. hemprichii \) with the density value was 1576 stands/m\(^2\) and the least found was \( C. serrulata \) it only 22 stands/m\(^2\), while for \( E. acoroides \) the density value was 171 stands/m\(^2\). If it compared with the results of previous research in 2015, in same sites and same seagrass
ecosystem areas, it was recognized that the most dominant seagrass species was *Enhalus* sp. with the density value was 1943 stands/m² and the least found was *Thalassia* sp. 321 stands/m², and the density value for *Cymodocea* sp. was 1908 stands/m², and the presence of seagrass species *Halophila* sp. with the density value was 220 stands/m² [9].

Table 1. Types and Density of Seagrass in Research Sites

| Species                  | Density (stands/m²) | Relative Density (RD) (%) |
|--------------------------|----------------------|---------------------------|
| *Enhalus acoroides*      | 171                  | 9.67                      |
| *Thalassia hemprichii*   | 1576                 | 89.09                     |
| *Cymodocea serrulata*    | 22                   | 1.24                      |

Thus, it can be seen that seagrass density in the waters of Teluk Awur Bay was decreased for these 2 years. The continued consequences of the destruction of the seagrass ecosystem can affect the distribution and abundance of fish and another biota that associated with the seagrass.

3.3. Conditions of Water

Fish data was collected from morning to evening, the conditions of water on this research sites can be seen from the observation of environmental parameters. The environmental parameters data collection was performed simultaneously with the fish data, waters parameters data were presented in Table 2 below.

Table 2. Data of Environmental Parameter Range in Research Sites.

| Parameters   | Range         |
|--------------|---------------|
| Temperature  | 29-30℃        |
| Salinity     | 30-31 ppt     |
| DO           | 4.1-4.3 mg/L  |
| pH           | 7-8           |
| Current      | 0.16-0.19 m/s |
| Depth        | 50-75 cm      |
| Brightness   | 38-60 cm      |

3.4. Frequency Distribution

The samples that observed for three months was mullets type *M. dussumieri* amounted to 347 fish, it was done every 2 weeks interval. The number of mullet fish caught in small amounts also affected by an uneven distribution of frequencies, so that not all classes of hoses can be represented by the caught mullet.

Body length class interval of mullet *M. dussumieri* was 1.3 cm, starts from the smallest class hose was 8 – 9.3 cm until the longest class hose was 27.6 – 28.9 cm. The most common frequencies of mullet found in class hose 10.8 – 12.1 cm, with a total of 61 fish that dominantly have the length of the body.

The frequency distribution of fish body size was also done in measuring body weight of mullet fish, body weight mullet type *M. dussumieri* caught in this research had interval 16.2 grams, started from the smallest class hose was 5 – 12.2 grams until the longest class hose is 233.2 – 249.4 gram. A total of 40 mullet fish have the dominant body weight in an interval of 5 – 12.2 grams. Based on this frequency distribution data it was known that the average fish size was relatively small. These fish was estimated to be young, so the seagrass ecosystem suspected as the enlargement and feeding ground, while spawning was done at sea. However, the data distribution based on weight of the fish was not as determinant as of the rate of growth of mullet, because according to von Bertalanffy’s model body length is a function of age [7].
The growth of mullet can be seen from the frequency distribution chart which was then arranged in order so that it can be seen the cohort. Fish body length considered as fish age, so that the cohort chart used to find out a growth of mullet was fish length-based cohort [8].

![Length Cohort Chart of Mullets (M. dussumieri); a) 16 October 2016; b) 30 October 2016; c) 13 November 2016; d) 27 November 2016; e) 11 December 2016; f) 25 December 2016](image)

**Figure 1.** Length Cohort Chart of Mullets (*M. dussumieri*); a) 16 October 2016; b) 30 October 2016; c) 13 November 2016; d) 27 November 2016; e) 11 December 2016; f) 25 December 2016

### 3.5. Growth Parameter Estimation

Growth parameter was analyzed by FISAT II software to determine the value of $K$ and $L_\infty$. The value of growth parameter on mullets represented by the following **Table 3**.

**Table 3.** The Value of Growth Parameter on Mullet (*M. dussumieri*)

| Parameters | Value       |
|------------|-------------|
| $K$        | 0.33 per year |
| $L_\infty$ | 30.24 cm    |
| $t_0$      | -0.305 per year |

According to growth parameter shown on the table, von Bertalanffy equation became $L_t = 30.24 \left(1-\exp(-0.33(t+0.305))\right)$ with graphic growth curve was represented by **Figure 2**.
Figure 2. Growth Curve of Mullet (\textit{M. dussumieri}).

The fish growth parameter (K) connected to asymptotic length (L\textsubscript{\infty}), that represents the maximum length until the fish full-grown, and \(t_0\) is the estimation period when its 0 cm length. The minimum K value indicates that Mullet fish had slow growth rate and long life period (around 11 years) to reach its asymptotic length.

If it compared with the previous research, the asymptotic length of mullet in the waters of the Banger River Estuary was 29.1 cm [10], while the mullet in Ujung Pangkah Water had K value 0.82 per year and L\textsubscript{\infty} was 39.39 cm, as the result mullets could reach its asymptotic length by 5.5 years [11].

The fundamental models used are based on four parameters: Growth, recruitment, natural and fishing mortality. Age and growth are particularly important for describing the status of a fish population and for predicting the potential yield of the fishery. It also facilitates the assessment of production, stock size, recruitment to adult stock and mortalities [12]. The growth is the result of all the physiological mechanisms by which any living organism increases its substance which is continuous when it lasts. Growth is a process of major fish biology and is a key process in structured model focusing on length [13].

The difference between growth parameter values caused several factors, factors that act to increase the biomass of a fish stock include growth, reproduction, and recruitment. Meanwhile, many factors in the marine environment act to reduce the chances of survival of individuals in a population. These include adverse conditions, lack of food, competition and, perhaps most important of all in marine species, predation [14]. The difference between L\textsubscript{\infty} and K value caused by the maximum length that obtained on the samples, the fishing ground, the samples amount, stocks and different recruitments.

3.6. Mortality Value Estimation

According to this research it can be known that average length of the samples (\(L\)) was 14.2 cm and length of the smallest fish in the sample (\(L'\)) is 8 cm, so it could be determined the total mortality rate (Z), and from this calculation it can discover Natural Mortality value (M), Fishing Mortality (F) and its Exploitation Rate (E).

The fish’s growth is a positive aspect of stock’s dynamic, and the negative aspects are disease and mortality. The key parameter to describe the fish mortality is mortality rate. Z is the coefficient that used to describe the total amount of death, and the coefficient of death caused by capture is F, and the death caused by nature is M [7]. The total mortality rate from mullet in Teluk Awur Bay water was 0.854 per year, while the natural mortality (M) was 0.706 per year and the fishing mortality (F) was
0.148 per year. Empirical equation represents that the small fish had high natural mortality and when the temperature around the area is rising, it will affect the natural mortality [8].

Based on this data it can be known that the natural mortality was higher than the fishing mortality. High mortality rates imposed on mature individuals, through factors such as exploitation, can alter these characteristics and ultimately change the response of fish populations to their physical environment [15]. The higher natural mortality is attributed to factors like diseases, old age, predation, spawning stress, and starvation. Most of these causes are connected with the ecosystem where it lives. The same species in different places may have different rate of natural mortality depending on the density of detritus and prey whose wealth is swayed by fishing activities [16].

The exploitation rate could explain the state of fish stock in the water. If the exploitation rate exceeds the optimum number which is 0.5, it means that area is overfishing. The optimum exploitation happens when the fishing mortality (F) is equal to its natural mortality (M) [7]. The exploitation rate is an index, which estimates the level of utilization of a fishery. The value of exploitation rate is based on the fact that sustainable yield is optimized when the fishing mortality coefficient is equal to natural mortality [12]. The mullet exploitation rate in Teluk Awur Bay was around 0.173 per year, it still in safe-exploitation rate, which means only around 17.3% of the mortality in Teluk Awur Bay caused by human catch activity.

4. Conclusion

As the results, mullet (M. dussumieri) growth rate in Teluk Awur Bay, Jepara were, for growth coefficient was 0.33 per year with asymptotic length (L∞) 30.24 cm, and the imaginary fish period when its 0 cm length (t0) was -0.305. The mullet mortality rate was more caused by the natural mortality (M) with 0.706 per year from the total mortality (Z) which was 0.85 per year and fishing mortality (F) only 0.148 with exploitation rate 0.173 which means that only 17.3% mullet mortality in Teluk Awur Bay, Jepara caused by human catch activity.

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