Population dynamics of snakehead (*Channa striata*) and marble goby (*Oxyeleotris marmorata*), their management in Bilibili Reservoir, South Sulawesi

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Abstract. Bilibili Reservoir in Gowa Regency, South Sulawesi, has multipurpose functions. This study aims to estimate population dynamic parameters of snakehead and marble goby fish. Research and data collection were carried out from March to August 2020. Fish samples were obtained from fishermen's catch using gill nets, longlines and nets. Analysis using Microsoft Excel data processing application and FISAT program. The results for snakehead fish, infinity length (L_∞) 41.16 cm, growth coefficient (K) 0.6 per year and theoretical age (t_o) 0.24 years. Natural mortality rate (M) is 1.188 per year, the total mortality (Z) is 2.51 per year. Mortality due to fishing is 1.322 per year and exploitation rate is 0.52. As for marble goby fish, infinity length (L_∞) is 33.91 cm, growth coefficient (K) is 0.64 per year, and the theoretical age (t_o) is 0.24 per year, natural mortality rate (M) is 1.308 per year, total mortality (Z) is 2.63 per year, mortality due to fishing is 1.322 per year, and exploitation rate is 0.50. Management of snakehead fish in Bilibili Reservoir can be done by: regulations on the use of fishing gear and methods or may be limited by fishing quotas, while the marble goby fish, can be used more as a highly nutritious consumption fish.

1 Introduction

Population parameters are usually used to study population dynamics. The parameters to be considered include abundance, yield, age composition, growth, recruitment, and mortality [24]. Population parameters such as: growth, recruitment and mortality, are needed for making regulations regarding fishing related to seasons and quotas, as well as for analyzing fishing strategies. [21]. High and excessive exploitation of fish resources in public waters has resulted in the degradation of fish resources [1]; [7]; [25];[17].

Bilibili Reservoir is a reservoir with a main dam of rock-fill type height of 76 m. The catchment area is 384.4 km^2 , with an inundated area of 18.5 km^2 and an adequate depth of

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36.6 m [3]. Bilibili Reservoir is in Gowa Regency, South Sulawesi and towards the upstream confluence of the Jeneberang and Jenelata Rivers [15]. Since the inundation began in 1998, Bilibili Reservoir has become a target for exploiting fishery products. Based on [2], there are 6 species of fish that live in Bilibili Reservoir, and all of them are consumption fish, namely: *Oreochromis niloticus* (65%), *Cyprinus carpio* (17%), *Osteochilus vittatus* (8%), *Barbonymus gonionotus* (4%), *Channa striata* (4%) and *Oreochromis mosambicus* (2%). During research in 2020, marble goby (*Oxyleotris marmorata*) fish were also found with a high population.

Snakehead and marble goby fish are predatory fish living in Bilibili Reservoir waters. Both types of fish are consumption fish, especially snakehead fish, which are caught and collected to be sent to Makassar as material for making albumin. Both types of fish play a role in the food chain because they are predatory valuable fish for the balance of the ecosystem in Bilibili Reservoir. High exploitation will affect the fish population, ultimately affecting other fish populations in Bilibili Reservoir.

The aim of this research is to obtain information regarding the dynamics of snakehead and marble goby fish populations and their management in the Bilibili Reservoir, South Sulawesi.

2 Methodology

2.1 Location of Research and Data Collections

This research is survey-explorative, including primary and secondary data, also information collection. The study was conducted from March until August 2020 in Bilibili Reservoir, Goa Regency, South Sulawesi Province, coordinate 5°16'35.70"S 119°34'50.09"E (Figure 1). Data was collected using a survey method (stratified sampling method). During the study, fish samples were collected from local fishers. Fish samples were obtained from various types of fishing gear such as gill nets, longlines and nets. Catch data were obtained through direct observation in the field and interviews with fishers. The total length of marble goby fish and snakehead fish was measured monthly. Samples taken during the research were 162 snakehead fish and 253 marbled goby fish.

2.2 Analysis of Data

The infinite growth value L_∞ and the growth coefficient K are obtained from the corrected length frequency which is then adjusted to the classical Von Bertalanffy Growth Function (VBGF). Growth of fish with the Von Bertalanffy Model according t_o [23]; [14]; [8]; [10]; [16]; [5], by setting the infinite length value (L_∞) and the growth constant value (K). Analysis of growth parameters using the FISAT-II program (version 1.2.2).

$$L_t = L_\infty (1 - e^{-k(t-to)})$$

The values of L_∞ and K were obtained from the calculation results using the ELEFAN 1 (Electronic Length Frequency Analysis) method contained in the FiSAT II program. L_t is the length at age t, L_∞ is infinite length, e is an exponential constant with a value of 2.718, K is the growth constant value, and t_0 is the theoretical age at zero length.. The empirical equation used by Pauly (1984) is referred to in [23], namely:

$$Log\,(-t_0) = -0.3922 - 0.2752 \log L_\infty - 1.036 \log K$$

2.3 Mortality rates

The Z was assessed based on the length converted catch curve result. The empirical formula of Pauly (1980) was used to determine the value of M or the natural mortality rate:

$$log_{10} M = -0.0066-0.279\ log_{10} L_\infty +0.6543\ log_{10} K+0.4634\ log_{10} T$$

M = natural mortality (year^{-1}), and T = average water temperature (taken at 29 °C). For the fishing mortality rate was computed using the formula [11]:

$$F = ZM$$

Z is total death (1st year), F value is death due to fishing (1st year), and M value is natural death (1st year). The exploitation rate or E is estimated based on [11]:

$$E = F/Z$$

Estimation of the total mortality rate Z was calculated using the catch curve method converted to length [23] and using the Beverton and Holt (1957) formula:

$$Z = K\ (L_\infty - L)/(L - L')$$

Information : K = Von Bertalanffy growth curve index
L_∞ = infinity length
L = average length of fish in a certain age group
L_c = length of first fish caught by device
L' = the length of the smallest fish in the sample with the number already can be calculated/representative

Estimates for the natural death parameter or M were obtained based on Pauly's (1984) empirical equation:

$$Log\ (M) = -\ 0.0152 - 0.2790\ Log\ (L_\infty) + 0.6543\ Log\ (\ K\ ) + 0.4634\ Log\ (\ T)$$

Information: M = natural mortality/year
L_∞ = infinity length (mm)
K = growth coefficient/year
T = annual average temperature

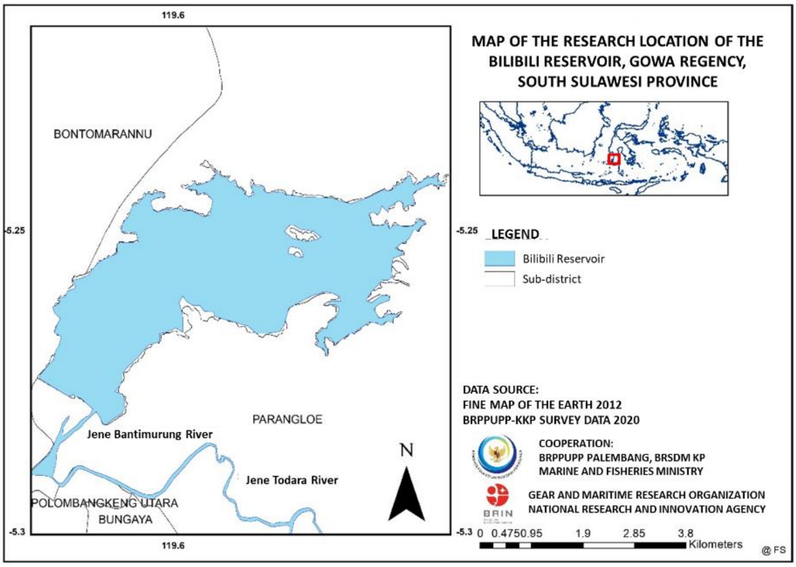

Fig. 1. Map of Research Locations

3 Results and Discussion

Based on the analysis of population dynamics parameters for marble goby fish and snakehead fish, the results are shown in Table 1.

Table 1. Population Dynamic Parameters of Marble goby fish and snakehead fish in Bilibili Reservoir

English name	Local name	Latin name	t (^{o}C)	L (cm)	K	M	Z	F	E
Snakehead fish	Gabus	*Channa striata*	29	41.16	0.6	1.18	2.51	1.32	0.52
Marble goby fish	Betutu	*Oxyeleotris marmorata*	29	33.91	0.64	1.3	2.63	1.32	0.50

A total of 162 fish samples were caught during the study, with a length range of 14 cm to 37 cm. Infinite length (L_∞) is 41.16 cm, the value of the growth coefficient or K is 0.6 per year with a theoretical age of 0.24 years (Figure 2). Based on these three parameters, the growth model for snakehead fish in the Bilibili Reservoir based on the Von Bertalanffy equation is: $L_t = 41.16*(1-exp(-0.6*(t-0.24)))$. Furthermore, by adding these parameter values and entering the average value of water temperature in Bilibili Reservoir, which is 29 ºC, the value of the natural mortality rate (*M*) is obtained at 1.188 per year.

Further analysis of total mortality (*Z*) was carried out using the length converted catch curve model, which was 2.51 per year. Mortality due to fishing is 1.322 per year and the exploitation rate (*E*) is 0.52. The exploitation rate of 0.52 indicates that the level of utilization of snakehead fish in Bilibili Reservoir is above the optimum point (0.50). [11] said that the E value of Snakehead fish, which exceeds 0.50 indicates that the fish is overfished. This is due to the high demand for snakehead fish as a raw material for albumin production (Figure 3 & 4).

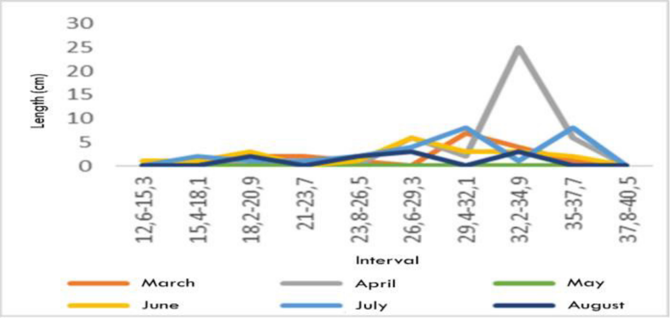

Fig. 2. Class Snakehead Fish Length

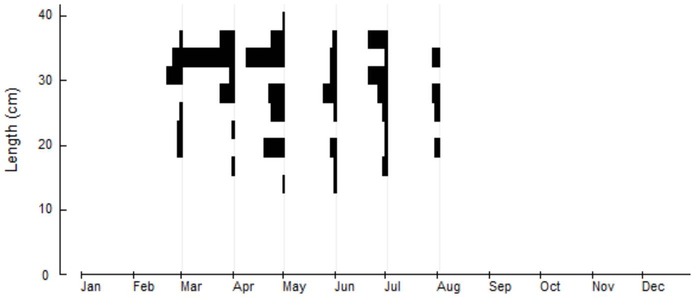

Fig. 3. VBGF and Plot Length Frequency

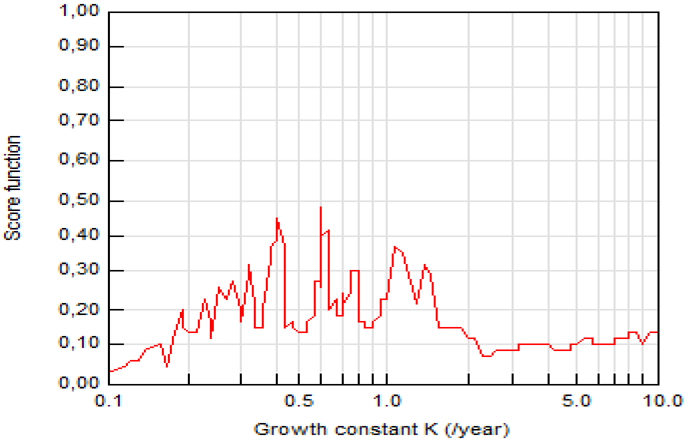

Fig. 4. Length and Growth Parameters (K)

The marble goby fish is a carnivore fish that lives on the bottom of the waters. Marble goby fish was introduced in Bilibili Reservoir in 1927. A total of 253 fish samples were used during the study, with a minimum length of 18.8 cm and a maximum of 31.3 cm (Figure 5).

Infinite length or L_∞ is 33.91 cm, the growth coefficient or K value is 0.64 per year with a theoretical age (t_o) of 0.24 years (Figure 6). With these 3 parameters, the growth model for Marble goby fish in Bilibili Reservoir follows Von Bertalanffy equation: $L_t = 33.91*(1-exp^{(-0.64*(t-0.24))})$.

Furthermore, by adding these parameter values and entering the average water temperature value in Bilibili Reservoir, which is 29 ºC, the natural mortality rate (M) is obtained at 1.308 per year. Total mortality or Z value using the catch length conversion curve model is 2.63 per year. Deaths due to fishing are 1,322 per year with an exploitation rate or E of 0.50. The exploitation rate of 0.50 indicates that the utilization rate of Marble goby in Bilibili Reservoir has reached an optimum point (Figure 7).

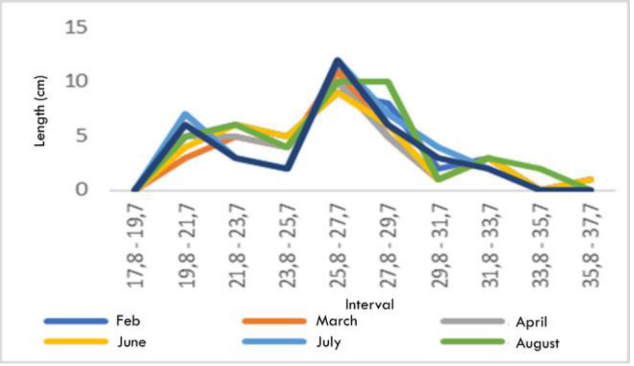

Fig. 5. Long Class of Marble Goby Fish

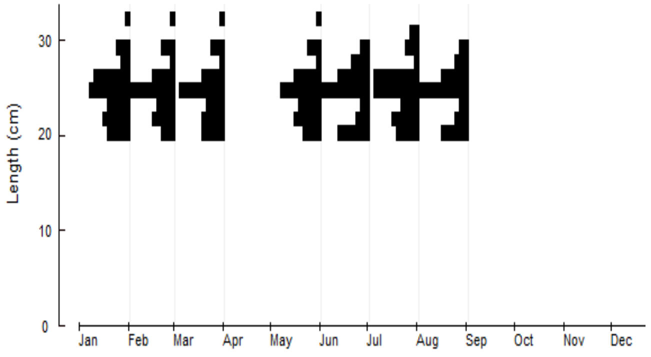

Fig. 6. VBGF and Length Frequency Plots

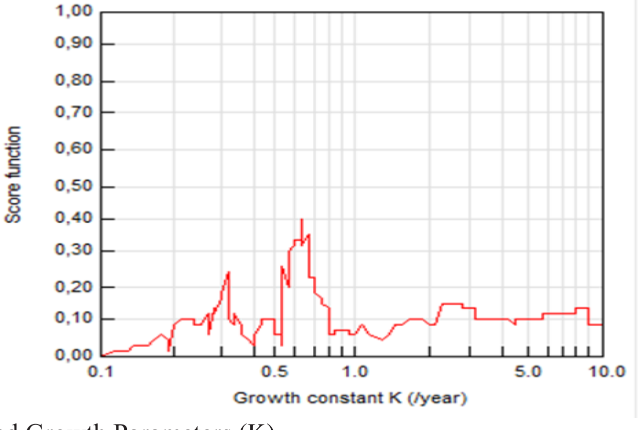

Fig. 7. Length and Growth Parameters (K)

The infinity length of snakehead fish in Panggang Lake, South Kalimantan, is much higher, namely L_∞ = 63.4 cm [22] compared to L infinity (L_∞) of snakehead fish in Bilibili

Reservoir of 41.16 cm. This difference is due to the availability of more food in the waters of Panggang Lake, which is a type of flooded swamp. Flooded swamp provide a source abundant natural food for fish, because it is overgrown with aquatic plants. It is a habitat for insects and fish which is a food source for many fish. Flooded swamp waters generally have higher fertility and productivity than reservoir waters. Based on the exploitation rate (E) value of snakehead fish in Bilibili Reservoir of 0.52 which is different from the E value in Panggang Lake, South Kalimantan of 0.62, which means that it has experienced a tendency of over fishing, due to the high demand as a consumption fish and for its albumin. Based on [12], most cases of over-exploitation are caused by human activities.

In contrast to marble goby fish, the snakehead fish in Bilibili Reservoir has a high selling price. Apart from being a consumption fish, the catch is also sent to Makassar as material for making albumin. Snakehead fish has an albumin fraction of 64.61% protein. This amount is very high when compared to other animal protein sources. In blood plasma, albumin is the most abundant type of protein. When compared with other types of fish, snakehead fish have a higher albumin content. [20]. The high rate of exploitation of snakehead fishing needs to be considered so that the population is not reduced by regulating the use of tools and methods of fishing or possibly being limited by catching quotas so that it remains sustainable.

The Marble goby fish in Bilibili Reservoir has not been used much, the population is quite large at this time. Based on the Exploitation Rate (E) value of marble goby fish = 0.50, it is still below the E value of snakehead fish = 0.52. The Marble goby fish is less preferred as a consumption fish, so the population is still quite high. This can also be seen from the maximum size of fish caught which is 31.3 cm, when compared to the Soedirman Banjarnegara Reservoir, Central Java, which is 28.4 cm [18].

Several factors cause the difference in the maximum length of the fish. Based on [26] and [9], the differences in fish size can be caused by adaptation to abiotic conditions such as water temperature and food availability. The Marble goby fish in Sumatra and Kalimantan is a consumption fish with a high price because marble goby fish has a high nutritional content such as protein. Utilization of these fish, in addition to maintaining ecological balance, can also increase people's income.

Based on [6] and [4], if fishing pressure is insufficient, therefore, creating markets can increase economic importance, and this can prevent further invasions reduce fishing pressure on native species, most of which are already overfished.

Habitat management also needs to be done for snakehead and marble goby in Bilibili Reservoir. Environmental conditions of fish habitat are very influential on fish mortality and birth, this is of course related to the amount of production and fish populations in these waters. Based on [13], The main challenge for fisheries managers today is how to determine fish populations that are influenced by habitat conditions. Preserving fish communities requires preserving fish habitat.

4 Conclusion

The infinity length of the snakehead fish is 41.16 cm. The Marble goby fish is 33.91 cm, with the exploitation level of the snakehead fish is 0.52, while the marble goby fish being 0.50, which means snakehead fish level utilization in Bilibili Reservoir is above the optimum point. Management of snakehead fish in Bilibili Reservoir can be done by: regulations on the use of fishing gear and methods or may be limited by fishing quotas, while the marble goby fish, which has an exploitation level below the snakehead fish, can be used more as a highly nutritious consumption fish.

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