BIODIVERSITAS
Volume 24, Number 5, May 2023
Pages: 2855-2864

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d240540

Length-weight relationships and condition factors of brackish water catfish, *Mystus gulio* (Hamilton, 1822) from three different estuaries, West Java, Indonesia

EPA PAUJIAH[1,♥], YAYAT DHAHIYAT[2], TITIN HERAWATI[2], ISKANDAR[2], HARYONO[3], ILHAM ZULFAHMI[4], FAHRI[5]

[1]Department of Agriculture, Universitas Padjadjaran. Jl. Raya Bandung Sumedang Km 21, Jatinangor, Sumedang 45363, West Java, Indonesia. Tel.: +62-227-796316, ♥email: epapaujiah@uinsgd.ac.id.

[2]Department of Fisheries Resources Utilization, Universitas Padjadjaran. Jl. Raya Bandung Sumedang Km. 21, Jatinangor, Sumedang 45363, West Java, Indonesia

[3]Research Center for Biology, National Research and Innovation Agency. Jl. Raya Jakarta-Bogor Km. 46, Cibinong Science Center, Bogor 16911, West Java, Indonesia

[4]Department of Fisheries Resources Utilization, Faculty of Marine and Fisheries, Universitas Syiah Kuala. Jl. Putroe Phang, Darussalam, Banda Aceh 23111, Aceh, Indonesia

[5]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Tadulako. Jl. Raya Soekarno-Hatta, Tondo, Palu 94117, Central Sulawesi, Indonesia

Manuscript received: 14 March 2023. Revision accepted: 24 May 2023.

Abstract. *Paujiah E, Dhahiyat Y, Herawati T, Iskandar, Haryono, Zulfahmi I, Fahri. 2023. Length-weight relationships and condition factors of brackish water catfish,* Mystus gulio *(Hamilton, 1822) from three different estuaries, West Java, Indonesia. Biodiversitas 24: 2855-2864.* This study investigated the biometric condition of brackish water catfish (*Mystus gulio* Hamilton 1822) collected from three different estuaries in Cianjur District, West Java Province, Indonesia. Data (class interval, growth pattern, and factor condition) were sorted based on time, location, and season. Water quality parameters measured include temperature, conductivity, TDS, hardness, resistivity, pH, DO, total oxygen, ORP, and salinity. The correlation between K-Value and water quality parameters was analyzed using multivariate analysis. Our results showed that the worth pattern of *M. gulio* was allometric, with condition factors value ranging from 0.904-1.042. There were variations in the growth patterns according to time, location, and fish sex. The lowest condition factor values were found in August for males and April for females. Meanwhile, the highest condition factor values were found for males on 4 June 2022 and 5 February 2022 for females. The NMDS analysis places the water resistivity and conductivity on a different axis from other environmental factors. The results of our study suggest that the estuaries in Cianjur District were adequate for supporting the survival and growth of *M. gulio* by providing food and suitable habitat.

Keywords: Condition factors, estuaries, growth pattern, *Mystus gulio*, water environment

INTRODUCTION

Estuaries are particular fish habitat (Whitfield 2015) that has special characteristics such as constant changes in water characteristics (Montagna et al. 2018; Setyadi et al. 2021) and the anthropogenic activities occurring around the river (Talke and Jay 2020; Hasan et al. 2023). Several estuaries on Java Island, especially in West Java, have a fairly high-water discharge, as with river estuaries in Cianjur District. Based on the field observation, the water discharge of several estuaries in the Cianjur District area depends on the season, as is the case in other estuaries (Conroy et al. 2020; Fettweis et al. 1998; Paujiah et al. 2019). The water discharge rises during the rainy season, and flash floods occasionally damage settlements around the estuary, as happened in the South of Pamekasan (Islamy and Hasan 2020) and the coast of Lamongan District (Isroni et al. 2023).

Hydrologically, Cianjur District has several large estuaries, including the Estuary of Ciujung, Cipandak, and Cidamar, which have potential biological resources, especially fishery resources. *Mystus gulio* Hamilton 1822, locally known as *keting* fish or *lundu* is one of the common fish found in global estuaries, including Cianjur District (Hossain et al. 2015; Paujiah et al. 2019). It has been documented in several countries, such as Bangladesh, India, Malaysia, Singapore, Vietnam, Thailand, Sri Lanka, Pakistan, and Myanmar (Hossain et al. 2015). Outside of West Java, this fish is distributed in the Cilacap (Suryandari and Tjahjo 2013) and Banten area (Lestari et al. 2021). Our preliminary study and interviews with fishing communities in the Cianjur District revealed that *M. gulio* is found in small estuaries and is used as a daily nutritional source for people around that estuary. In addition, this fish is cultivated in Bangladesh and has become a highly commercial fish (Gupta 2014). Furthermore, Keting fish are an ecological bioindicator species for heavy metals contaminations (Lestari et al. 2021).

Information on the biometric condition of fish (class interval, growth patterns, factor condition) is crucial for bioecological studies. For example, fish fatness can be affected by environmental conditions such as environmental variability (Lestari et al. 2021). In addition, the growth pattern of *Mystus* spp. (*Mystus bleekeri* Day 1877), *Mystus cavasius* (Hamilton 1822), *Mystus tengara* (Hamilton 1822), and *Mystus vittatus* (Bloch 1794)) is also influenced by environmental variability (Rao 2017). However, natural food variables such as the availability of plankton organisms and the spawning season are the main factors that influence growth patterns in several fish species (Hasim et al. 2021; Lall and Tibbetts 2009; Nogales-Mérida et al. 2019).

Previous studies have investigated length-weight relationships and the condition factor of *M. gulio*. For instance, The length-weight relationships and condition factor of *M. gulio* have been reported by Begum et al. (2009), which was taken from the fish market in Bangladesh. However, data reported by Gupta (2014) revealed that the growth pattern of this fish is allometric. Furthermore, the fish habitat reported by previous researchers showed a different condition from this study. Therefore, it is suspected that there are differences in growth patterns and condition factors of *M. gulio* from several estuaries in Cianjur, West Java, Indonesia. Moreover, no thorough investigation has been conducted on the effect of the season to length-weight relationship and the effect of water variables on condition factors of *M. gulio.* Therefore, this study aimed to report the length-weight relationships, condition factors, and correlation of water variables to condition factor values of *M. gulio* in the Estuary of Cianjur District, West Java, Indonesia. Therefore, we investigated the length-weight relationships of *M. gulio* from several estuaries in Cianjur District, West Java, and its correlation with the water variable, which will be used for fishery management in the study area.

MATERIALS AND METHODS

Study site and fish collection

This research was conducted from October 2021 to November 2022 and was located in three estuaries in the Cianjur District, West Java, Indonesia, namely the Estuary of Cidamar, Cipandak, and Ciujung (Figure 1). At Cidamar and Cipandak estuary, the direct confluence between seawater and river water only happens under certain conditions, such as the rainy season. In contrast, at Ciujung estuary, the direct confluence between seawater and river water occurs continuously. In addition, Cidamar and Cipandak estuaries were surrounded by local sand mining and dense residential areas, while Ciujung was surrounded by shrimp ponds and fairly dense residential areas. Data collection on the length and weight of fish was carried out in the UIN Sunan Gunung Djati Bandung integrated laboratory. For each location, sampling was conducted at two points based on the estuary section (at the end of the estuary and the area at the beginning of the estuary). The first sampling area was located at the mouth of the estuary (high salinity), while the other sampling point was located in a mixed area of seawater and fresh water. The distance between the sampling point ranged from 1,000-1,500 meters.

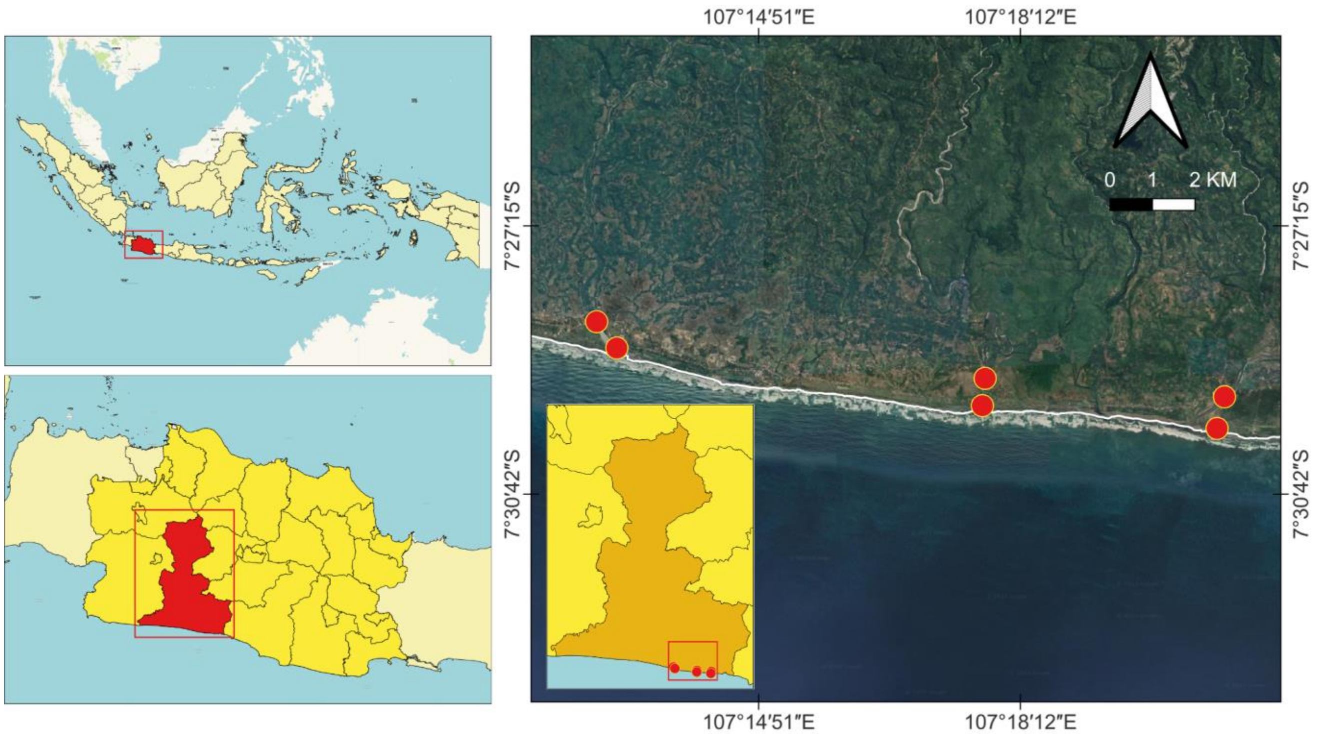

Figure 1. Map of research site in Cianjur estuaries, West Java, Indonesia

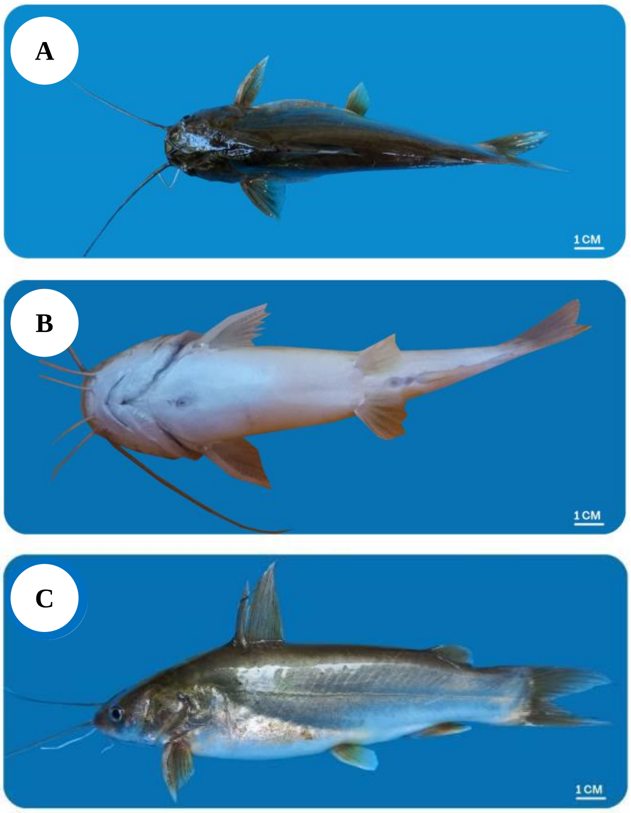

Figure 2. *Mystus gulio* from Cianjur estuaries, A. Dorsal view, B. Ventral view, C. Lateral view

Procedure

Keting fish (*M. gulio*) was identified using an identification key book from Kottelat and Whitten (1996) and Eschmeyer's catalog of fishes (2023) (Figure 2). Fish samples were caught using several fishing gears, including gill nets with mesh sized 0.75", castanets, and fishing rods. The samples obtained were preserved using alcohol (70%) and transferred to the laboratory for further analysis. The total length (from tip of mouth to tail) and weight of the fish were measured using calipers and analytical balance at an accuracy of 1 mm and 0.01 g, respectively (Alavi-Yeganeh et al. 2018). In addition, fish sex was determined by dissecting the fish gonads. The animal care approved this study and use committee of the State Islamic University, Sunan Gunung Djati Bandung, Indonesia.

Data on characteristics of the aquatic environment were obtained in situ using the LUTRON WAC-2019SD Water Quality Recorder. The water variables analyzed consisted of temperature (°C), conductivity (µS/cm), TDS (ppm), hardness (ppm), resistivity (Ω/ohm), pH, DO (mg/L), total oxygen (O2), ORP (mV) and salinity (ppt).

Data analysis

Data on the relationship between fish length and weight follows the equation $W = aL^b$, where W = Fish weight (g), L = Total length (cm), a and b are constant (Alavi-Yeganeh et al. 2018). Fulton's equation determined the condition factors:

$$K = 100\frac{W}{L^3}$$

Where: K is condition factors, W is the fish weight (g), L is the total length (cm), and -3 is the length coefficient (Suleiman et al. 2018).

FISAT II was used to analyze the condition factors. Multiple statistical techniques were employed to observe the relationship between water quality variables and K-Value, as has been done by Sabha et al. (2022). Data are presented as the range. Furthermore, to visualize the relationship between water quality parameters and K-Value, we performed non-metric multidimensional scaling (NMDS) scattergram using the function "metaMDS" under the Vegan package (Oksanen et al. 2013). NMDS was chosen because this analysis technique does not require assumptions about the transformation function; the only assumption is the data processed in ranking or ordinal data (Dexter et al. 2018; Kenkel and Orlóci 1986). Besides, the Pearson correlation test was conducted to show the pair-wise correlations between K-Value and each water parameter. The correlation was performed using the "cor" function under the Corrplot package (Wei et al. 2022). All these statistical analyses were computed using R-studio software.

RESULTS AND DISCUSSION

Variation in fish size

Variations in fish size are illustrated in length intervals shown in Figure 3. The result showed that *M. gulio* fish length was dominated by intervals of 7.1-9 cm in the Cidamar. Followed by 9.1-11 in the Ciujung and 11.1-13 in the Cipandak. However, based on the sample's maximum length during the study, there were fish with a maximum size range of 19.1-21 cm. Finally, Figure 4 shows that the weight interval of *M. gulio* fish at the three locations is relatively the same, dominated by fish weights less than 31.8 g.

The interval length of *M. gulio* during the rainy season, especially January and February, varied in size (six class intervals) compared to other months. Meanwhile, during the dry season, especially in July, the samples caught were also diverse in size between the months (Figure 5 and Figure 6). Therefore, based on time, the lowest fish weight intervals were obtained in December, January, and April, while the maximum weight was mostly found in July and September (Figure 7 and Figure 8).

Length-weight relationships

The growth pattern of *M. gulio* based on time and sex is presented in Table 1. Based on sex, *M. gulio* growth pattern was categorized as allometric negative and positive for both males and females ($b>3$ and $b<3$). The determinant coefficient (r^2) value indicated that the total length and weight of the fish have a strong relationship with the range r^2 between 0.732-0.971. The r^2 of the LWR regression varied between 0.457-0.975 for males and 0.717-0.977 for females, indicating a moderate to strong length-weight relationship. The pattern of fish growth based on location (Table 2, Figure 9) showed a value of $b<3$ (2.673-2.786) or negative allometric with r^2 values for the estuaries of the Ciujung, Cipandak, and Cidamar of 0.865, 0.869, and 0.722 (strong correlation) respectively.

Condition factors

The fish condition factors based on time showed that *M. gulio* was in the range of 0.904-1.042 for male fish and 0.993-1.029 for female fish. These values indicate that the fish obtained at the study site were physically categorized as less flat to slightly fat.

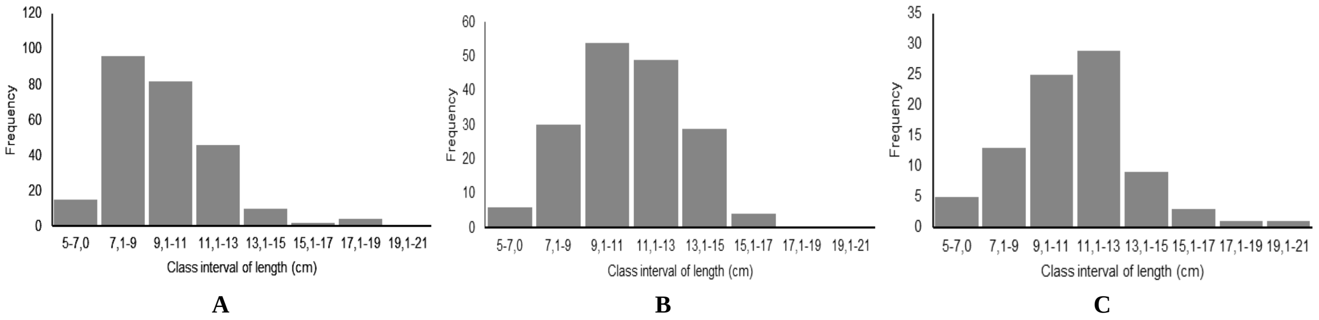

Figure 3. Range of the total length of M. gulio in the estuaries of: A. Cidamar (CDM); B. Ciujung (CIU); and C. Cipandak (CPD)

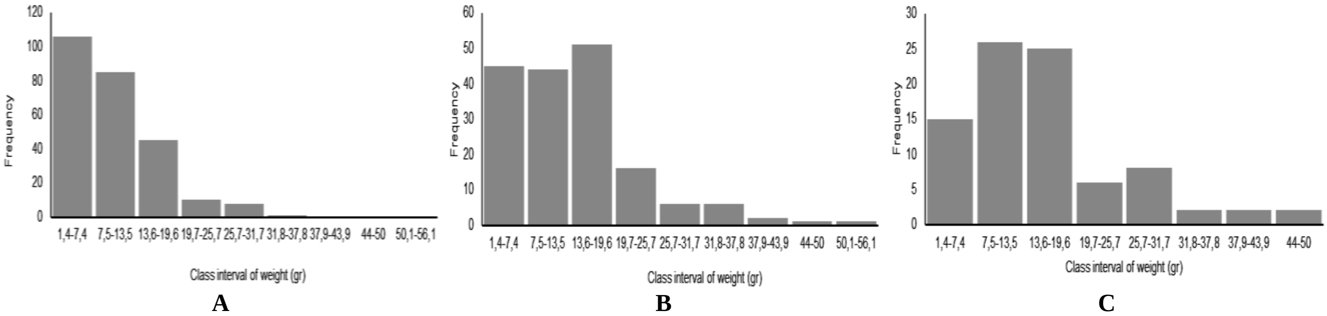

Figure 4. Range of weights of *M. gulio* in the estuaries of: A. Cidamar (CDM); B. Ciujung (CIU); and C. Cipandak (CPD)

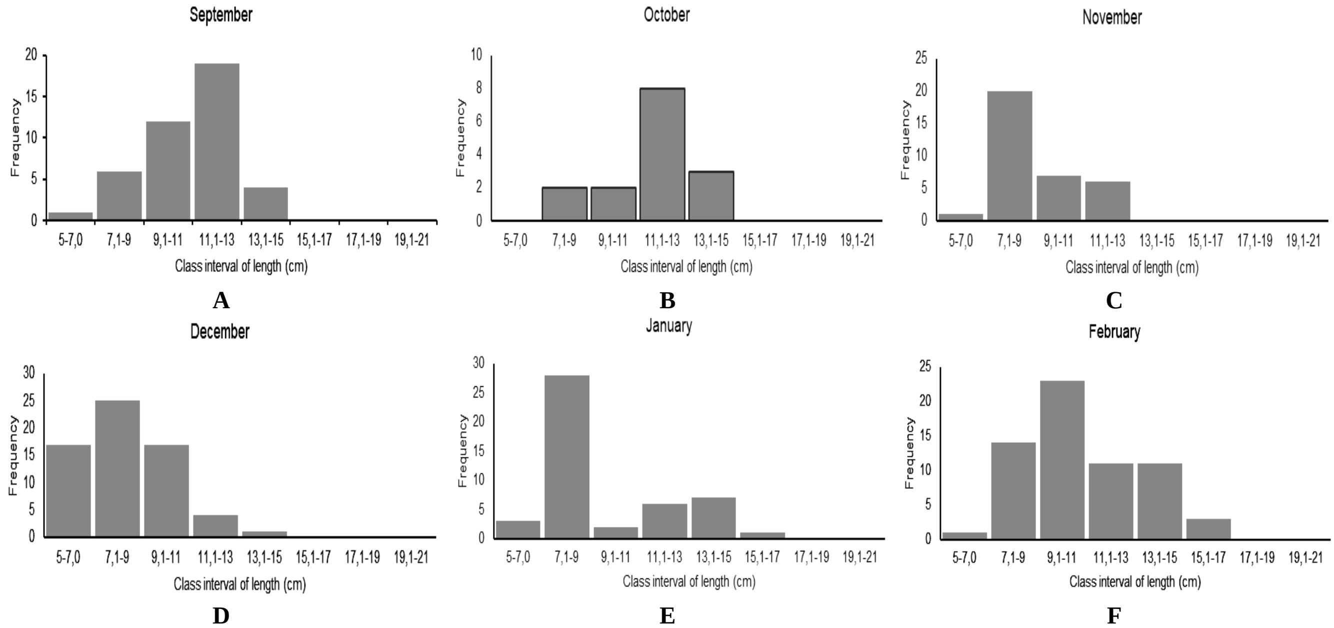

Figure 5. Distribution of the total length of *M. gulio* during the rainy season

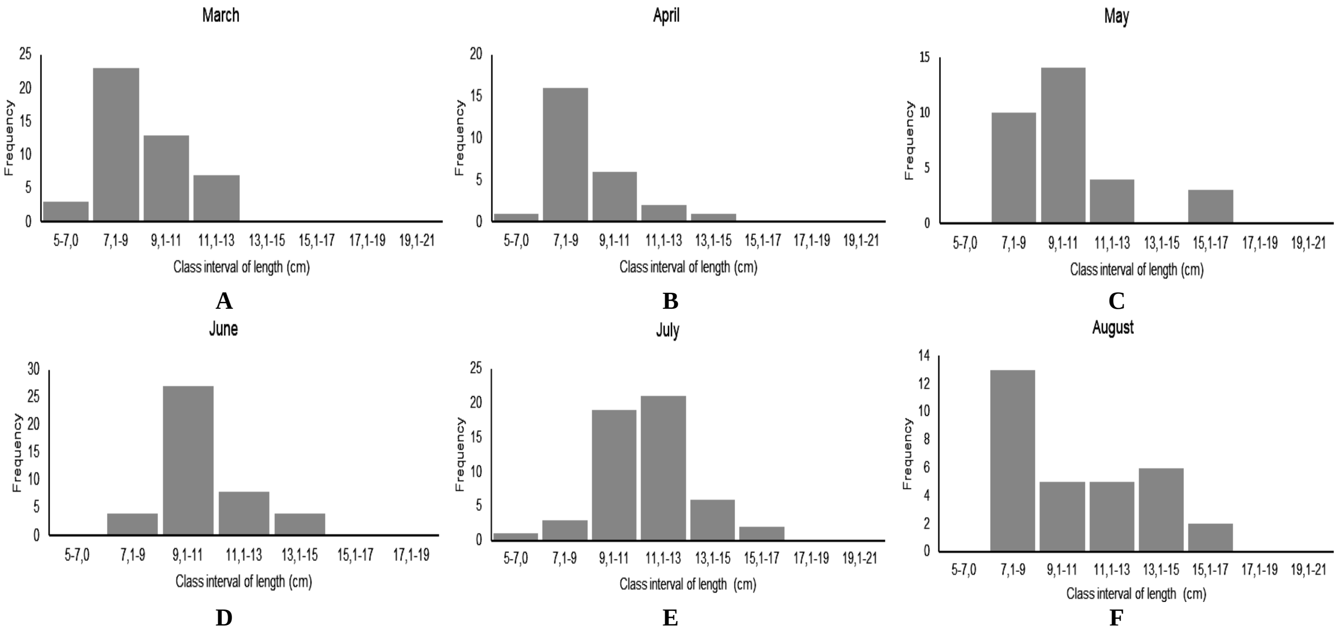

Figure 6. Distribution of the total length of *M. gulio* during the dry season

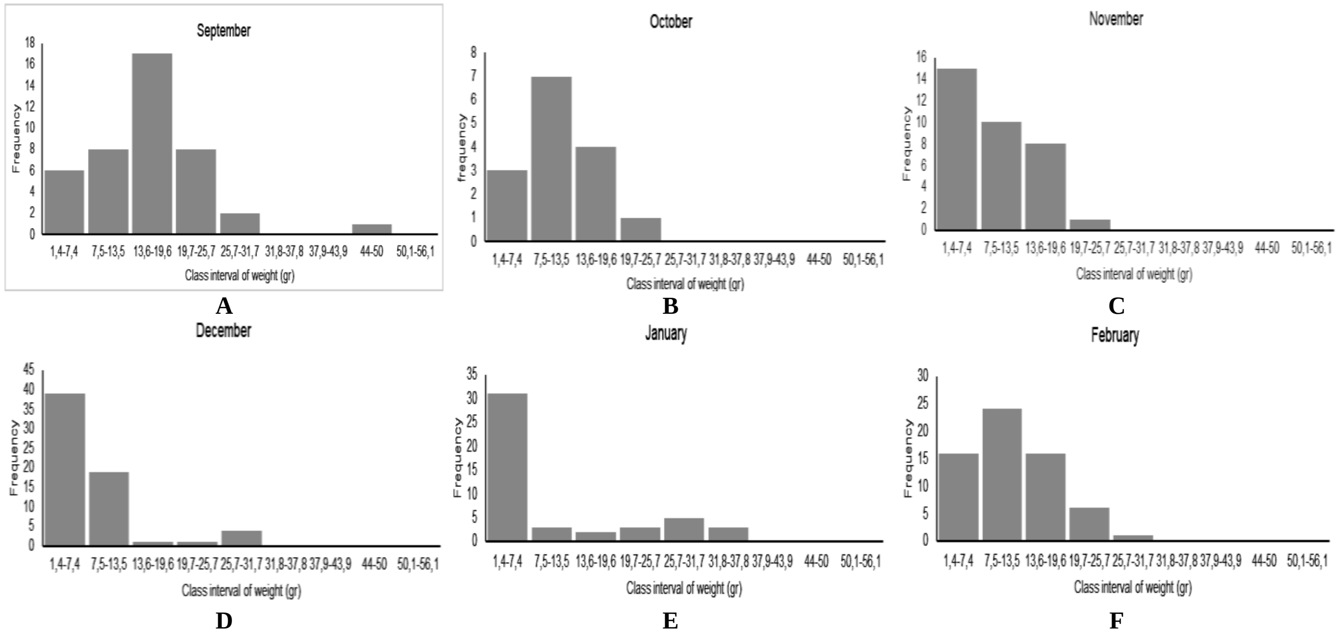

Figure 7. Distribution of the total weight of *M. gulio* during the rainy season

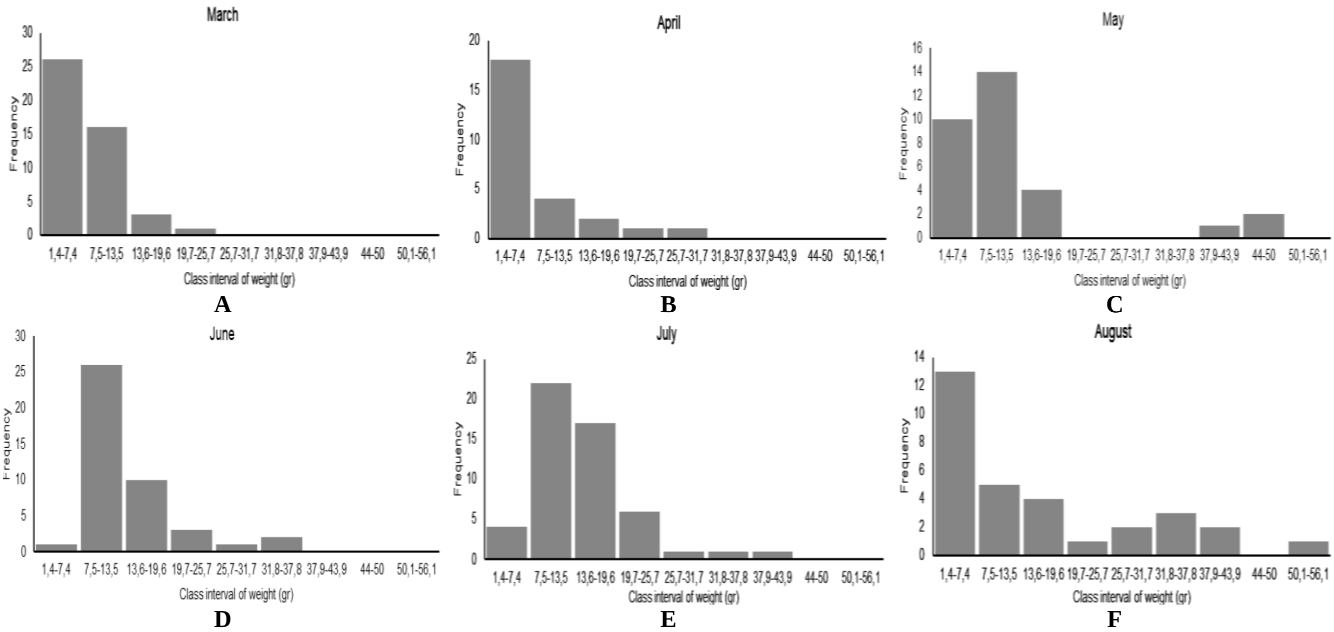

Figure 8. Distribution of the total weight of *M. gulio* during the dry season

Table 1. Sex, number of specimens (n), minimum and maximum length, maximum and minimum weight, a value, b value, correlation value and K-value for each month, NA= Negative Allometric (b<3), IS=Isometric(b=3), PA= Positive Allometric (b>3)

Month	Sex	n	Total Length		Weight		a	b	95%b	r^2	K	Growth pattern
			Min	Max	Min	Max						
October 2021	Male	7*	9.0	13.0	5.3	13.4	0.009	2.867	2.04-3.7	0.538	1.006	NA
	Female	8*	7.6	14.0	5.1	20.4	0.054	2.226	1.8-2.56	0.904	1.003	NA
	Both	15	7.6	14.0	5.1	20.4	0.027	2.471	0.43-0.47	0.892	1.011	NA
November 2021	Male	10	7.3	12.5	4.0	14.5	0.043	2.397	1.19-3.6	0.725	1.022	NA
	Female	24	5.0	12.5	2.3	20.0	0.063	2.219	1.71-2.73	0.787	1.032	NA
	Both	34	5.0	12.5	2.3	20.0	0.059	2.248	1.81-2.69	0.774	1.029	NA
December 2021	Male	11	5.9	11.0	2.0	12.4	0.006	3.219	2.76-3.68	0.966	0.999	PA
	Female	53	5.2	14.7	1.4	30.0	0.015	2.849	2.55-3.14	0.966	1.029	NA
	Both	64	5.2	14.7	1.4	30.0	0.013	2.901	2.64-3.16	0.890	1.027	NA
January 2022	Male	10	6.6	13.5	2.9	27.0	0.006	3.178	2.79-3.56	0.975	1.016	PA
	Female	36	5.5	15.5	1.4	41.0	0.005	3.321	3.12-3.52	0.970	1.001	PA
	Both	46	5.5	15.5	1.4	41.0	0.005	3.280	3.11-3.45	0.971	1.015	PA
Febuary 2022	Male	18	8.7	15.0	6.3	17.7	0.081	2.007	1.62-2.39	0.883	1.008	NA
	Female	45	6.2	16.6	3.5	26.8	0.079	2.065	1.67-2.46	0.717	1.044	NA
	Both	63	6.2	16.6	3.5	26.8	0.082	2.036	1.72-2.35	0.732	1.034	NA
March 2022	Male	15	6.4	13.0	3.0	13.0	0.052	2.189	1.09-3.28	0.592	1.033	NA
	Female	31	7.0	20.1	2.4	20.1	0.010	2.918	2.62-3.22	0.931	1.009	NA
	Both	46	6.4	20.1	2.4	20.1	0.017	2.706	2.36-3.05	0.849	1.016	NA
April 2022	Male	15	7.3	12.3	3.1	21.3	0.004	3.418	2.53-4.31	0.951	1.020	PA
	Female	31	7.0	15.0	2.4	30.7	0.004	3.374	3.11-3.64	0.977	0.993	PA
	Both	46	7.0	15.0	2.4	30.7	0.003	3.424	3.16-3.68	0.968	0.996	PA
May 2022	Male	14	8.0	12.9	6.8	19.5	0.292	1.571	0.48-2.66	0.457	1.033	NA
	Female	17	7.8	17.1	6.3	47.9	0.009	3.054	2.66-3.45	0.948	1.011	PA
	Both	31	7.8	17.1	6.3	47.9	0.026	2.603	2.11-3.1	0.948	1.031	NA
June 2022	Male	24	7.7	14.7	5.5	34.0	0.086	2.110	1.66-2.79	0.668	1.042	NA
	Female	19	9.1	14.6	9.1	33.4	0.012	2.981	2.33-3.63	0.845	1.006	NA
	Both	43	7.7	14.6	9.1	33.4	0.033	2.527	2.09-2.96	0.770	1.018	NA
July 2022	Male	29	6.0	14.6	2.0	29.4	0.015	2.776	2.44-3.12	0.912	1.014	NA
	Female	24	10.1	15.9	11.6	40.7	0.043	2.420	1.79-3.05	0.754	1.013	NA
	Both	53	6.0	15.9	11.6	40.7	0.013	2.862	2.54-3.19	0.864	1.018	NA
August 2022	Male	12	7.3	11.3	4.3	16.7	0.010	3.016	2.16-3.87	0.862	0.904	PA
	Female	19	7.1	16.5	3.9	55.1	0.010	3.061	2.67-3.43	0.946	1.022	PA
	Both	31	7.1	16.5	3.9	55.1	0.007	3.188	2.91-3.46	0.951	1.015	PA
September 2022	Male	25	9.0	14.5	6.9	27.0	0.043	2.404	1.59-3.22	0.617	1.020	NA
	Female	17	6.8	14.8	4.7	48.8	0.012	2.973	2.42-3.53	0.897	1.027	NA
	Both	42	6.8	14.8	4.7	48.8	0.019	2.763	2.33-3.19	0.808	1.023	NA

Note: * = Sampling was carried out after the occurrence of flash floods at the research location

Table 2. Sex, number of specimens (n), minimum and maximum length, maximum and minimum weight, a value, b value, correlation value, and K-Value at each location, NA= Negative Allometric (b<3), IS=Isometric(b=3), PA= Positive Allometric (b>3)

Location of Estuary	Sex	n	L		W		a	b	95%b	r^2	K	Growth Pattern
			Min	Max	Min	Max						
Ciujung	Male	68	5.7	14.7	2.0	34.0	0.023	2.602	2.32-2.88	0.574	1.028	NA
	Female	104	6.0	16.5	2.0	55.1	0.010	2.958	2.4-3.23	0.816	0.946	NA
	Both	172	5.7	16.5	2.0	55.1	0.015	2.786	2.62-2.95	0.865	1.025	NA
Cidamar	Male	108	6.4	18.0	1.2	27.0	0.049	2.296	1.92-2.67	0.587	1.079	NA
	Female	147	5.2	18.6	1.4	41.0	0.032	2.464	2.25-2.68	0.785	1.048	NA
	Both	255	5.2	18.6	1.4	41.0	0.036	2.424	2.24-2.61	0.722	1.060	NA
Cipandak	Male	26	7.7	13.5	4.6	27.0	0.020	2.731	2.11-3.36	0.772	1.031	NA
	Female	60	5.0	26.5	2.0	48.8	0.029	2.553	2.27-2.84	0.849	1.055	NA
	Both	86	5.0	26.5	2.0	48.8	0.028	2.573	2.33-2.82	0.869	1.045	NA

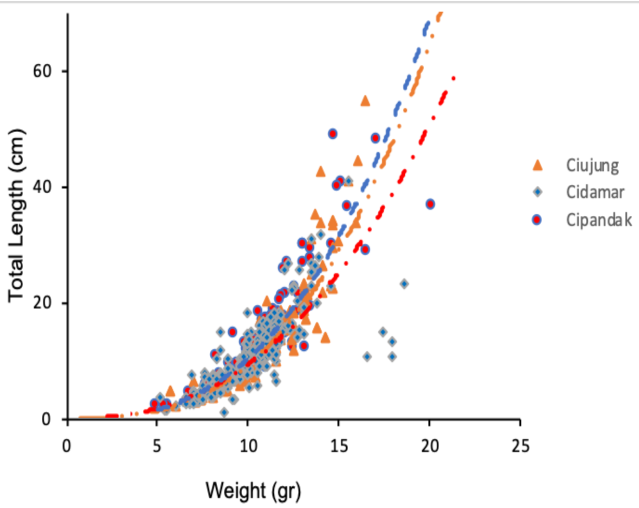

Figure 9. Length-weight relationship of *M. gulio* in the estuary of Cipandak, Cidamar, and Ciujung

The relationship between condition factors and the aquatic environment

The results of the NMDS analysis (Figure 10) between the K-value each month and the observed environmental factors show that from all the water parameters analyzed, the resistivity and conductivity parameters are in a separate axis position compared to other environmental factors. Both factors were noticed approaching the K-Value in August. Table 1 shows that the condition factors value in August is the highest compared to other months. Likewise, environmental factors such as water resistivity and water conductivity in August showed the highest values compared to other months. At the same time, other environmental factors appear to be clustered at one point and away from the K-Value. Therefore, based on the correlation analysis between condition factors and environmental factors revealed that pH, resistivity, TDS, and hardness have positive correlation values compared to other environmental factors, even though the correlation values are in a low category (<0.2 of 1). That shows all the environmental factors analyzed have a low effect on the condition factors of the keting fish (*M. gulio*) that impact their length and weight.

The analysis of each aquatic environment parameter in Table 3 shows a wide range of water parameters with high fluctuations. Several important-water variables values (DO, pH, and TDS) show values following class 4 water quality standards (fisheries). Therefore, these three components fall into the good category for the life of organisms in the fisheries.

Table 3. Range value of water variables from all sites in the Cianjur estuaries from October 2021-September 2022

Parameters	Ciujung estuary	Cipandak estuary	Cidamar estuary	Water Quality Standard
Physics				
Temperature (°C)	22,2-33,6	24,90-32,10	24,30-34,30	Dev 3*
Conductivity (µS/cm)	0,29-86900	0,42-115200	0,25-1208000	300-500) x 10-6 (Ωm)-1****
TDS (ppm)	114,80- 1005,00	4,10-567	1,49-817,00	2000*
Hardness (ppm)	93,20-750,00	2,45-422	4,70-612,00	Very hard***, max 500*****
Resistivity (Ω/ohm)	21,55-215520,00	22,45-10711000,00	6,17-13222000	3 x 103****
Chemical				
pH (unit)	7,07-9,55	7,64-10,39	6,92-10,20	6-9*
DO (mg/L)	>9,90	>11,80	>7,90	Minimum of 1*
Oxygen (O2)	27,40-100,60	28,00-93,50	22,20-100,00	absent
ORP (mV)	-145,00-185,00	-189,00-215,00	-186-190,00	absent
Salinity (ppt)	0-1,36	0-1,64	0-0,60	5,0-35**

Note: * = Sulastri et al. (2016); ** = Nybakken (1992); *** = http://www.state.ky.us/nrepc/water/ramp/rmhard.htm; **** = Syech et al. (2016); = *****WHO

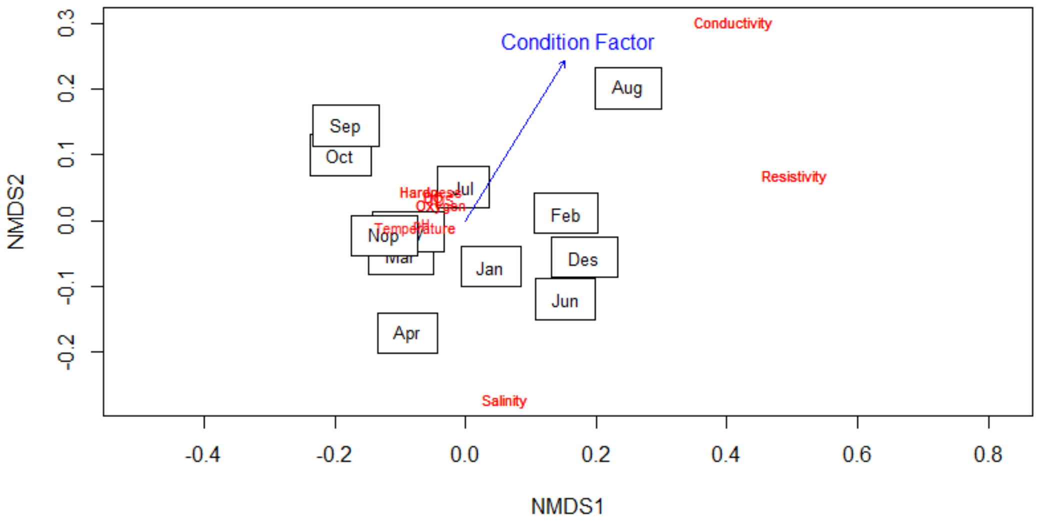

Figure 10. Non-metric Multidimensional Scaling (NMDS) ordinary of K-value at the different months with water variabilities

Discussion

Variation in fish size

Furthermore, 513 samples of *M. gulio* were used to analyze the length-weight relationship and condition factors. This fish was caught from three estuaries, namely the estuaries of Ciujung, Cipandak, and Cidamar. This fish can also be found in smaller estuaries based on information from the community near the estuary. Furthermore, based on its distribution, this fish could live in estuaries with low-salinity waters (Gupta 2014). The result showed that based on location, the length of the *M. gulio* obtained in this study ranged from 7.1-21 cm. These results were relatively similar to a study by Begum et al. (2009) in Bangladesh, even though the weight of the *M. gulio* found in this study was smaller than in Bangladesh, which reached a weight of 65 g.

Length-weight relationships

The b value explains the growth pattern of fish; if the value of b > 3 indicates a positive allometric growth pattern, b < 3 is negative allometric, and b = 3 isometric (Hasim et al. 2021). However, this study revealed no isometric growth patterns were found in *M. gulio*, as stated in the study by Gupta (2014). Therefore in this study, the growth pattern of *M. gulio* based on sex, time, and location generally showed an allometric growth pattern, similar to the research by Hasim et al. (2021) and Verma and Prakash (2019) that the growth pattern of *M. gulio* is allometric.

Condition factors

Fish condition factors are generally influenced by internal and external (environmental) conditions, as reported by several researchers. For example, Hasim et al. (2021), Mobley et al. (2021), and Yulianto et al. (2020) stated that fish condition factors can be influenced by several factors such as gender, gonads maturity, climate, and food. In addition, the condition factor values obtained describe the biological condition of the fish associated with fish welfare. The condition factor also describes the quantity and quality of fish meat availability (Effendie 2002).

Based on the location and time, there was no condition factor less than 1 indicating the conditions in the three estuaries could support the survival of *M. gulio*. However, this data is also supported by similar studies from other researchers on keting fish in other locations to determine estuaries' ability to support fish survival. Begum et al. (2009) reported that the K-value for *M. gulio* fish ranged from 0.8 to 1.2, followed in this study. Further, the increase or decrease in K-Value may be due to metabolic strain during maturation or spawning and changes in feeding activity. Suleiman et al. (2018) stated several factors influence condition factors in fish, including water quality, chemistry, biology, natural food, and fish exploitation. This condition was also observed in several fish species' earlier studies by Gupta and Banerjee (2013), Muchlisin et al. (2017), and Wang et al. (2021). For the next study, the researcher should discuss condition factors' K' in 'pre-spawning' and 'spent' conditions, particularly in females during the breeding season.

The relationship between aquatic environmental parameters and the condition factors

The environmental factors analyzed have a low effect on the condition factors of the keting fish (*M. gulio*). Therefore, it is suspected that other environmental parameters were not analyzed in this study, which could influence the conditional factors of *M. gulio*. Moreover, K-values are not constant for individuals, species, and populations but are subject to wide variations for fish of average natural conditions (Konan et al. 2017; Sekitar et al. 2015), such as feeding regime and gonadal development (Aga et al. 2017). Referring to the statement of Suleiman et al. (2018) and Muchlisin et al. (2017), factors that influence the condition of fish are several environmental parameters, but this study showed the contrary results. Therefore, fish condition factors can decrease due to several environmental parameters. For example, *Mystus* fish (namely *M. vittatus)* is exposed to heavy arsenic metals in water bodies (Verma and Prakash 2019). This compound was not an observed environmental variable in this study, so no information was obtained regarding the relationship between K-value and heavy arsenic metal. Other examples, in demersal and pelagic fish from the North Sea and Baltic Sea that ingested plastic, Rummel et al. (2016) reported no direct effect of plastic on the K value of fish. In *Tilapia zilii* Gervais, 1848 (syn. *Coptodon zillii* Gervais, 1848) and *Oreochromis urolepis* Norman, 1922 species, the environmental parameters that positively affect K-value are DO concentrations (Nehemia et al. 2012). However, these species differ from those in this study, so it is suspected that DO did not positively affect the *M. gulio* species.

Water resistivity and conductivity are two environmental factors close to the K-Value ordination. In addition, the month of August is the only time (month) that is close to the K-Value ordination. The high K-Value in August was followed by high resistivity and conductivity values. The resistivity value or the resistance value is a value that indicates the ability of water to inhibit electrical current. At the same time, conductivity is the ability of water to conduct an electrical current (Light 1984). The resistivity value obtained from this study is inversely proportional to the conductivity value. The greater the resistivity value, the smaller the conductivity value (Meschi et al. 2015). In addition, the higher the resistivity value, the higher the water purity level (Lane et al. 2020). High water purity indicates that the water can be used for human needs or animals around the study site, such as for drinking livestock and other domestic community activities around the estuary.

Therefore, many factors can greatly enhance and maintain the dynamics of the estuaries. That are including: maintaining good water quality parameters and their influx into the water system, sufficient regulation of fishing and its practice, non-selective gears restriction and enforcement by relevant authorities, and public enlightenment on the dangers of biodiversity loss.

Therefore, this study can be concluded that the growth pattern of *M. gulio* in the estuaries of Cianjur District is allometric. The condition factors (K-value) show that 90% of the identified *M. gulio* species have a K value above 1. Moreover, the water condition variables show a wide range of values, and the conditions can still be used for fishing activities. The NMDS analysis shows that the relationship between water variables and K-Value indicates a low correlation (<0.2). Water's resistivity and conductivity parameters are separated from other environmental factors, and these two factors are close to the K-Value in August. Further research is expected to observe other variables such as natural feed, fish development, and other aquatic environmental aspects to determine factors affecting the condition of *M. gulio* growth at this study location.

ACKNOWLEDGEMENTS

UIN Sunan Gunung Djati Bandung funded this research with Registration number 221160000049797 (BOPTAN-Litapdimas). The author would like to thank Kemal Ibrahim, Tb. Farhan, Dewi Hayatu Nupus, and Ahmad for excellent field technical assistance. The authors also thank Dindin Jamaluddin and Aan Hasanah were supporting this research. For author contributions, Epa Paujiah: study concept, design, and intellectual content; acquisition of data; analysis and interpretation of data; drafting and writing of the manuscript. Yayat Dhahiyat: discussion and critical revision of the manuscript. Titin Herawati: critical revision of the manuscript. Iskandar: critical revision of the manuscript. Haryono: critical revision of the manuscript. Ilham Zulfahmi: acquisition of some of the data. Fahri: critical revision of the manuscript and after review by the referees. Furthermore, all author has contributed substantially to the work. The author declares no competing interest. The funders had no role in the study's design; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

REFERENCES

Aga AF, Asha D, Meera DA. 2017. Efficacy of feeding frequency, feeding rates and formulated diets on growth and survival of rohu (*Labeo rohita*) brood stock under intensive rearing. Intl J Fish Aquat Stud 5 (1): 85-89.

Alavi-Yeganeh MS, Aazami J, Nemati VM, Nozarpour N. 2018. Length-weight and length-length relationships of *Oxynoemacheilus frenatus* (Heckel 1843) and *Petroleuciscus esfahani* Coad & Bogutskaya, 2010 from the Cheshmeh-Langan river, Iran. J Appl Ichtiol 34 (3): 768-770. DOI: 10.1111/jai.13607.

Begum M, Pal HK, Islam MA, Alam MJ. 2009. Length-weight relationship and growth condition of *Mystus gulio* (Ham.) in different months and sexes. Univ J Zool Rajshahi 28: 73-75. DOI: 10.3329/ujzru.v28i0.5292.

Conroy T, Sutherland DA, Ralston DK. 2020. Estuarine exchange flow variability in a seasonal, segmented estuary. J Phys Oceanography 50 (3): 595-613. DOI: 10.1175/JPO-D-19-0108.1.

Dexter E, Rollwagen-Bollens G, Bollens SM. 2018. The trouble with stress: A flexible method for the evaluation of non-metric multidimensional scaling. Limnol Oceanogr: Methods 16 (7): 434-443. DOI: 10.1002/lom3.10257.

Effendie I. 2002. Biologi Perikanan. Yayasan Pustaka Nusantara, Bogor. [Indonesian]

Eschmeyer. 2023. Eschmeyer's Catalog of Fishes. Institute for Biodiversity Science and Sustainability: California Academy of Sciences. https://research.calacademy.org/research/ichthyology/catalog/fishcatmain.asp.

Fettweis M, Sas M, Monbaliu J. 1998. Seasonal, neap-spring and tidal variation of cohesive sediment concentration in the Scheldt Estuary, Belgium. Estaur Coast Shelf Sci 47 (1): 21-36. DOI: 10.1006/ecss.1998.0338.

Gupta S, Banerjee S. 2013 Studies on reproductive biology of *Mystus tengara* (Ham.-Buch., 1822), a freshwater catfish of West Bengal, India. Intl J Aquat Biol 1 (4): 175-184. DOI: 10.22034/ijab.v1i4.69.

Gupta S. 2014. Morphology, growth pattern, feeding and reproductive biology of *Mystus gulio* (Hamilton-Buchanan, 1822) (Siluriformes: Bagridae). Intl J Aquat Biol 2 (4): 201-205. DOI: 10.22034/ijab.v2i4.86.

Hasan V, andraini NE, Isroni W, Sari LA, Nafisyah AL, Dewi NA, Putri DNA, Prsatati TAB, Ramadhani AA, Daniel K, South J, Vieira LO, Ottoni FP, Maftuch, Faqih AR, Wirbuana PYAP, Tamam MB, Valeb FS. 2023. Fish diversity of the Bengawan Solo River estuary, East

Java, Indonesia. Biodiversitas 24 (4): 2207-2216. DOI: 10.13057/biodiv/d240433.

Hasim H, Tuheteru J, Fazrin DN. 2021. Comparison of growth pattern, condition factor, gonadosomatic index of Manggabai (*Glosogobius giuris*) and Payangka (*Ophieleotris aporos*) in Limboto Lake, Gorontalo, Indonesia. Biodiversitas 22 (6): 3389-3393. DOI: 10.13057/biodiv/d220646.

Sulastri, Henny C, Handoko U. 2016. Environmental condition and trophic status of Lake Rawa Pening in Central Java. OLDI (Oseanologi dan Limnologi di Indonesia) 1(3): 23-28.

Hossain M, Islam R, Hossen M, Rahman O, Islam M, Alam M. 2015. Threatened fishes of the world: *Mystus gulio* (Hamilton, 1822) (Siluriformes: Bagridae). Croatian J Fish: Ribarstvo, Agronomski Fakultet Zagreb 73 (1): 43-45. DOI: 10.14798/73.1.792.

Islamy RA, Hasan V. 2020. Checklist of mangrove snails (Mollusca: Gastropoda) in south coast of Pamekasan, Madura Island, East Java, Indonesia. Biodiversitas 21 (7): 3127-3134. DOI: 10.13057/biodiv/d210733.

Isroni W, Sari PDW, Sari LA, Daniel K, South J, Islamy RA, Wirabuana PYAP, Hasan V. 2023. Checklist of mangrove snails (Gastropoda: Mollusca) on the coast of Lamongan District, East Java, Indonesia. Biodiversitas 24 (3): 1676-1685. DOI: 10.13057/biodiv/d240341.

Kenkel NC, Orlóci L. 1986. Applying metric and non-metric multidimensional scaling to ecological studies: some new results. Ecology 67 (4): 919-928. DOI: 10.2307/1939814.

Konan KJ, Eyi AJ, N'Da K ABC. 2017. Length-weight relationship and condition factor for 18 fish species from Ono, Kodjoboué and Hébé lagoons, Southeast of Ivory Coast. Intl J Fish Aquat Stud 5: 13-18.

Kottelat M, Whitten T. 1996. Freshwater Fishes of Western Indonesia and Sulawesi: Additions and Corrections. Periplus, Hong Kong.

Lall SP, Tibbetts SM. 2009. Nutrition, feeding, and behavior of fish. Veterinary Clinics of North America: Exotic Animal Pract 12 (2): 361-372. DOI: 10.1016/j.cvex.2009.01.005.

Lane JJW, Briggs MA, Maurya PK, White EA, Pedersen JB, Auken E, Terry N. 2020. Characterizing the diverse hydrogeology underlying rivers and estuaries using new floating transient electromagnetic methodology. Sci Tot Environ 740: 140074. DOI: 10.1016/j.scitotenv.2020.140074.

Lestari KO, Sulistiono S, Effendi H. 2021. Heavy metal (Hg, Cd, Pb, Cu) in the long whiskered catfish (*Mystus gulio* Hamilton, 1822) in Bojonegara Coastal Waters of Banten Bay, Indonesia. IOP Conf Ser: Earth Environ Sci 869: 12011. DOI: 10.1088/1755-1315/869/1/012011.

Light TS. 1984. Temperature dependence and measurement of resistivity of pure water. Anal Chem 56 (7): 1138-1142. DOI: 10.1021/ac00271a019.

Meschi AB, Trinidad J, Hu A, Zhou YN, Zhao B. 2015. Highly electrically conductive adhesives using silver nanoparticle (Ag NP)-decorated graphene: the effect of NPs sintering on the electrical conductivity improvement. J Mater Sci: Mater Electron 26 (1): 590-600. DOI: 10.1007/s10854-014-2440-y.

Mobley KB, Aykanat T, Czorlich Y, House A, Kurko J, Miettinen A, Moustakas-Verho J. 2021. Maturation in Atlantic salmon (*Salmo salar*, Salmonidae): a synthesis of ecological, genetic, and molecular processes. Rev Fish Biol Fish 31 (3): 523-571. DOI: 10.1007/s11160-021-09656-w.

Montagna PA, Hu X, Palmer TA, Wetz M. 2018. Effect of hydrological variability on the biogeochemistry of estuaries across a regional climatic gradient. Limnol Oceanogr 63 (6): 2465-2478. DOI: 10.1002/lno.10953.

Muchlisin ZA, Fransiska V, Muhammadar AA, Fauzi M, Batubara AS. 2017. Length-weight relationships and condition factors of the three dominant species of marine fishes caught by traditional beach trawl in Ulelhee Bay, Banda Aceh City, Indonesia. Croatian J Fish 75 (3): 142-154. DOI: 10.1515/cjf-2017-0014.

Nehemia-Maganira JD, Rumisha C. 2012. Length-Weight relationship and condition factor of tilapia species grown in marine and fresh water ponds. Agric Biol J North Am 3 (3): 117-124. DOI: 10.5251/abjna.2012.3.3.117.124.

Nogales-Mérida S, Gobbi P, Józefiak D, Mazurkiewicz J, Dudek K, Rawski M, Kierończyk B. 2019. Insect meals in fish nutrition Rev Aquacult 11 (4): 1080-1103. DOI: 10.1111/raq.12281.

Nybakken JW. 1992. Biologi Laut Suatu Pendekatan Biologis. Gramedia, Jakarta. [Indonesian]

Oksanen J, Blanchet FG, Kindt R, Legendre P, Minchin PR, O'hara RB, Simpson GL. 2013. Package 'vegan': Community Ecology Package, Version 2 (9): 1-295.

Paujiah E, Solihin DD, Affandi R. 2019. Community structure of fish and environmental characteristics in Cisadea River, West Java, Indonesia. Jurnal Biodjati 4 (2): 278-290. DOI: 10.15575/biodjati.v4i2.6096. [Indonesian]

PP No. 22 Tahun 2021. Penyelenggaraan Perlindungan dan Pengelolaan Lingkungan Hidup. Jakarta. [Indonesian]

Rao KR. 2017. Food and feeding habits of freshwater Catfishes (Siluriformes: Bagridae: *Mystus* sp.). Intl J Life Sci Sci Res 3 (1): 786-791. DOI: 10.21276/ijlssr.2017.3.1.7.

Rummel CD, Löder MGJ, Fricke NF, Lang T, Griebeler E-M, Janke M, Gerdts G. 2016. Plastic ingestion by pelagic and demersal fish from the North Sea and Baltic Sea. Mar Poll Bull 102 (1): 134-141. DOI: 10.1016/j.marpolbul.2015.11.043.

Sabha I, Hamid A, Bhat SU, Islam ST. 2022. Water quality and anthropogenic impact assessment using macroinvertebrates as bioindicators in a stream ecosystem. Water Air Soil Poll 233 (9): 387. DOI: 10.1007/s11270-022-05839-8.

Sekitar PKA, Hamid M, Mansor M, Nor SAM. 2015. Length-weight relationship and condition factor of fish populations in Temengor Reservoir: Indication of environmental health. Sains Malay 44 (1): 61-66. DOI: 10.17576/jsm-2015-4401-09.

Setyadi G, Rahayu DWIL, Pribadi R, Hartati R, Wijayanti DP, Sugianto DN, Darmawan A. 2021. Crustacean and mollusk species diversity and abundance in the mangrove communities of Mimika District, Papua, Indonesia. Biodiversitas 22 (10): 4146-4157. DOI: 10.13057/biodiv/d221004.

Suleiman N, Yola IA, Ahmed IM. 2018. Biodiversity and condition factor of fish species from Challawa Gorge Dam. Intl J Fish Aquat Stud 6 (3): 112-117.

Suryandari A, Tjahjo DWH. 2013. Hubungan panjang berat, makanan, dan sebaran ikan kating, *Mystus gulio* (Hamilton 1822) di Segara Anakan, Cilacap. Prosiding Seminar Nasional Ikan Ke 8: 41-47. [Indonesian]

Syech R, Emrinaldi T, Simbolon LF. 2016. Identifikasi kualitas air berdasarkan sifat fisik air Sungai Siak Pekanbaru. Komunikasi Fisika Indonesia 13 (12): 801-806. [Indonesian]

Talke SA, Jay DA. 2020. Changing tides: The role of natural and anthropogenic factors. Ann Rev Mar Sci 12: 121-151. DOI: 10.1146/annurev-marine-010419-010727.

Verma AK, Prakash S. 2019. Impact of arsenic on haematology, condition factor, hepatosomatic and gastrosomatic index of a fresh water cat fish, mystus vittatus impact of arsenic on haematology, condition factor, hepatosomatic and gastrosomatic index of a fresh water cat fish, Mystus. Intl J Biol Sci 10 (2): 49-54. DOI: 10.13140/RG.2.2.31567.10409.

Wang Y, Liang C, Xian W, Wang Y. 2021. Using the LBB method for the assessments of seven fish stocks from the Yangtze Estuary and its adjacent waters. Front Mar Sci 8 (634): 1-13. DOI: 10.3389/fmars.2021.679299.

Wei T, Simko V, Michael L, Yihui X, Jin Y, Zemla J, Freidank M. 2022. Package 'corrplot'. Statistician 56 (316): e24.

Whitfield AK. 2015. Why are there so few freshwater fish species in most estuaries?. J Fish Biol 86 (4): 1227-1250. DOI: 10.1111/jfb.12641.

Yulianto D, Indra I, Batubara AS, Efizon D, Nur FM, Riza, S, Elvyra R. 2020. Length-weight relationships and condition factors of mullets *Liza macrolepis* and *Moolgarda engeli* (Pisces: Mugilidae) harvested from Lambada Lhok waters in Aceh Besar, Indonesia. F1000Research 9: 259. DOI: 10.12688/f1000research.22562.1.