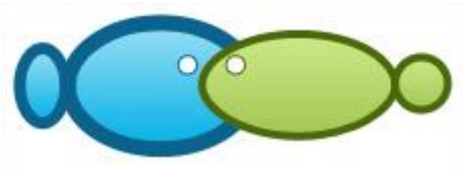

Length-weight relationship of nine species of the Nike fish school (post-larva Gobioidei) in Gorontalo Bay waters, Indonesia

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Abstract. This is one of the first studies to report the length-weight relationships (LWR) of 9 species that are present in the Nike school in Gorontalo Bay, Indonesia, namely: *Belobranchus belobranchus* (Valenciennes, 1837), *B. segura* (Keith, Hadiaty & Lord, 2012), *Bunaka gyrinoides* (Bleeker, 1853), *Eleotris melanosoma* (Bleeker, 1853), *Sicyopterus cynocephalus* (Valenciennes, 1837), *S. lagocephalus* (Pallas, 1770), *S. longifilis* (de Beaufort, 1912), *S. parvei* (Bleeker, 1853), and *Stiphodon semoni* (Weber, 1895). The samples were collected from the daily catch of fishermen during the spawning season between 2019 and 2022. The total length and weight of each sample were determined. Parameters a and b of the relationship between the length and weight of fish were calculated from the log-transformed equation with 95% confidence intervals. The value of b ranged from 1.341±0.272 to 2.963±0.323, indicating that all species had a negative allometric growth pattern. The LWR estimates can be useful for the management and conservation of Nike fish in the future.
Key Words: amphidromous, fisheries management, gobies, growth parameters.

Introduction. The Nike fish has been recognized as a Communal Intellectual Property Right (HKI) for Gorontalo Province with the Inventory Number SDG.01.2020.000001 since 2020. This acknowledgement by the Provincial Government of Gorontalo through the Ministry of Law and Human Rights of the Republic of Indonesia is one of the efforts to protect the potential of the region due to the consideration that fish resources appear seasonally, but they always have a high market demand. There has also been an increase in interest from the academic sector, where several studies have been carried out on Nike (Yusuf et al 2012; Tuina et al 2013; Salam et al 2016; Olii et al 2017; Pasisingi & Abdullah 2018; Olii et al 2019; Sahami et al 2019a; Sahami et al 2019b; Pasisingi et al 2020; Sahami et al 2020; Sahami & Habibie 2021). However, none of the studies explored the length-weight relationship (LWR) of the fish, referring to each species composing the Nike fish school.

LWR parameters of freshwater and marine fish have long been of interest to fisheries researchers (Masoumi et al 2021). Previous studies revealed that they have been used to assess the status of fish populations since the early 20th century (Froese 2006). They can be used to determine the growth rate, age, and other factors affecting population dynamics (Kolher et al 1995). Change in length or weight over time has also been used to assess population growth rates (Pepin 1995). Several studies also revealed that it plays a key role in fisheries assessment (Kolher et al 1995; Eagderi et al 2020; Xia et al 2022). In fishery science, the LWR can be used to calculate the total weight of fish based on length observations (Siddique et al 2014; Baek et al 2015). The LWR parameters also help to estimate the total biomass of an ecosystem (Froese 1998; Moutopoulos & Stergiou 2002) and estimate the condition factor of the fish (Famoofo & Abdul 2020). LWR can be used as primary data, which plays an important role in the study and conservation of fish in the future (Xiong et al 2015). Its estimation also has a very significant practical value in the management of fish (Lteif et al 2016; Tran et al

2021) and serve as input in fisheries evaluation and management models (Siddique et al 2014; Sepa et al 2022).

Although this information is very important, it is still unavailable for various regions and this can limit the planning as well as the implementation of sustainable fishery resource management (Sabido-Itzá et al 2021; De Santis et al 2022). Therefore, this study aims to estimate the LWR of the species in the Nike school of fish in Gorontalo Bay, Indonesia.

Material and Method. 150 g of samples were collected from fishermen catches daily during the Nike fish emergence season, which usually enters the new moon phase every month between 2019-2022, except in 2020 due to the covid-19 pandemic. The sampling location was in Gorontalo Bay's waters to the Bone-Bolango River's estuary, as shown in Figure 1. The collected samples were then preserved in an icebox and transported immediately to the Hydrobioecology and Biometrics Laboratory, Faculty of Fisheries and Marine Sciences, State University of Gorontalo, for identification and measurement of length and weight. The specimens were identified based on the method proposed by Sahami et al (2019b), Sahami et al (2020) Sahami & Habibie (2021), and Sahami et al (2022). The total length was measured using Image-J with an accuracy of 0.001 cm, while the weight was determined using a digital balance with an accuracy of 0.01 g.

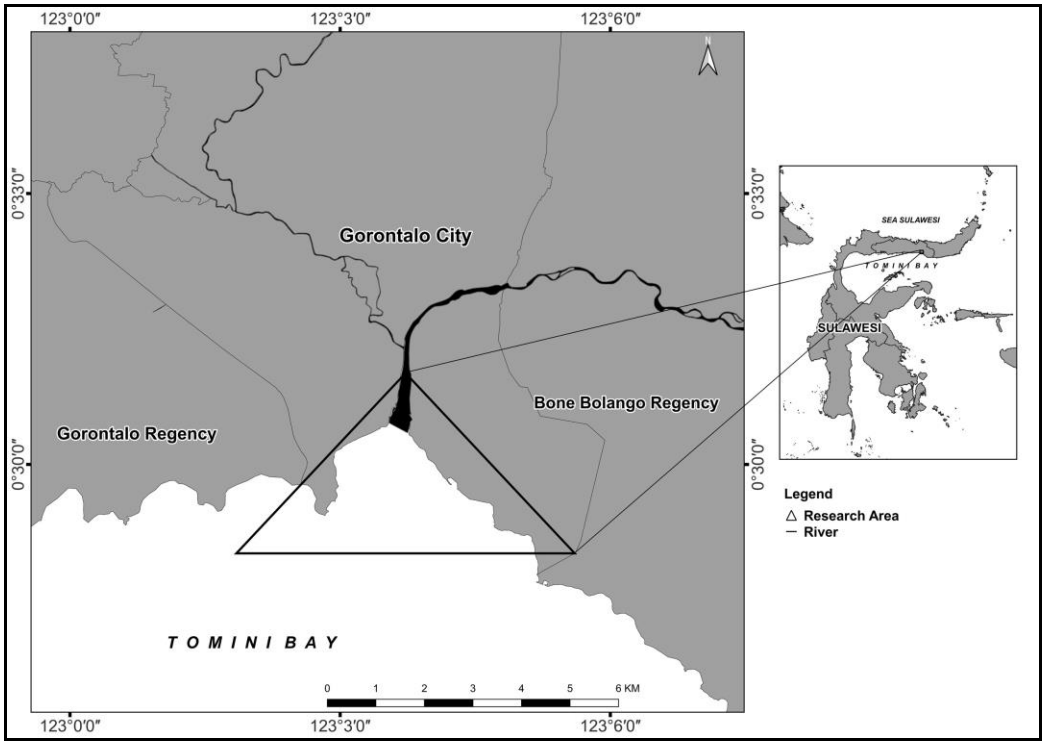

Figure 1. Nike fish sampling locations.

The model used to describe the LWR of fish is an allometric function (Pepin 1995; Effendie 2002; Froese 2006), as follows:

$$W = aL^b$$

Where: W - sample weight; L - total sample length; a and b - constants. The logarithmic transformation of this equation produced a linear relationship logW = log a + b logL. Values a and b were obtained from the regression analysis at a 95% confidence interval (CL) (Siddique et al 2015). Fish are categorized to have an isometric pattern if the constant value b=3 and an allometric pattern if the constant value b≠3, namely negatively allometric for <3 and positively allometric for b>3. The level of significance

between variables was determined based on the value of r^2. The data collected in this study were analyzed using Microsoft Excel 2010.

Results. 9453 samples of Nike fish with a size range between 1-4.815 cm were collected from the waters of Gorontalo Bay to the estuary of the Bone-Bolango River, and they consisted of 9 species, 5 genera, and 2 families. Gobiidae is a family that dominates Nike catches during the period of observation, and they accounted for 88.64% of the harvest, while Eleotridae had 11.36% of the composition. The 9 species that compose the Nike school were: *Belobranchus belobranchus*, *B. segura*, *Bunaka gyrinoides*, *Eleotris melanosoma* (Eleotridae), *Sicyopterus cynocephalus*, *S. lagocephalus*, *S. longifilis*, *S. parvei*, and *Stiphodon semoni* (Gobiidae). The length, weight, and LWR of each species are presented in Table 1.

Table 1

The length and weight relationship (LWRs) of nine fish species that make up the Nike fish school in Gorontalo Bay

Species	N	Total body length (cm)		Total body weight (g)		Parameters of the LWR				Growth
		Min	Max	Min	Max	a	b	SE	r^2	
Belobranchus belobranchus	364	1.576	3.515	0.01	0.46	0.01129	230.866	0.41306	0.57280	Allometric (-)
Belobranchus segura	619	1.357	3.935	0.01	0.45	0.02225	193.586	0.40188	0.61449	Allometric (-)
Bunaka gyrinoides	34	1.805	3.736	0.08	0.46	0.04917	147.698	0.27002	0.79176	Allometric (-)
Eleotris melanosoma	57	2.960	3.614	0.13	0.38	0.00660	280.088	0.19966	0.55791	Allometric (-)
Sicyopterus cynocephalus	1310	1.760	4.815	0.04	0.54	0.05614	134.092	0.27233	0.53557	Allometric (-)
Sicyopterus lagocephalus	16	2.800	3.200	0.19	0.26	0.02426	203.675	0.05797	0.82585	Allometric (-)
Sicyopterus longifilis	4158	1.316	4.694	0.02	0.42	0.04037	142.917	0.36859	0.50724	Allometric (-)
Sicyopterus parvei	877	1.000	4.019	0.11	0.92	0.03901	185.572	0.21990	0.62144	Allometric (-)
Stiphodon semoni	2018	1.321	2.399	0.01	0.18	0.00694	296.286	0.32265	0.61021	Allometric (-)

Note: LWR - length-weight relationship; a and b - parameters of the length-weight relationship; SE - the standard error of parameter b; r^2 - the coefficient of determination.

The results showed that the sample size varies for each species, with the shortest total length of 1 cm for *S. parvei*, while the largest, 4.815 cm, was recorded in *S. cynocephalus*. The value of parameter b ranged from a minimum of 1.34092 for *S. cynocephalus*, to a maximum of 2.96286 in *S. semoni*. The LWR showed a negative allometric growth pattern ($b<3$) for all species in the Nike fish school.

Discussion. Nike fish is one of the potential local fishery resources in the waters of Gorontalo Bay. It is also the favorite fish commodity of the community, but less attention has been paid to its sustainability. This fish community is composed of amphidromous gobies of the Gobiidae and Eleotridae families in the postlarvae to juvenile phases, with a length of 2-4 cm (Sahami et al 2019b; Sahami et al 2020). It often lives together in groups, which is a strategy for finding food and avoiding predators during migration (Keith 2003). In the tropics, most of the amphidromous fish belong to the families Gobiidae and Eleotridae (Sánchez-Garcés 2017). The high public interest in the consumption of this commodity has an impact on the effort to catch it without considering its sustainability (Sahami et al 2019b; Sahami et al 2020; Sahami & Habibie 2021). In some areas, the postlarvae stage of amphidromous gobies is a target for intensive fishing by traditional fishermen, during the migration process from the sea to river waters (Ellien et al 2016; Ellien et al 2019; Mennesson et al 2019; Roesma et al 2020; Sahami & Habibie 2021).

These gobies are important members of both freshwater and marine communities (Walter et al 2012), with high economic value and which contribute to the diversity of fauna in the river (Ellien et al 2019; Kovačić & Svensen 2019). However, biological and ecological studies of this fish are limited. The gap in biological information related to migration events is also an important aspect related to fishing activities. Sánchez-Garcés (2017) stated that fisheries for amphidromous species in South Columbia and North Ecuador, as well as in other East Pacific coasts, have not been well documented, and this is similar to the condition in Indonesia. These species are often neglected at the national level, but represent an important source of animal protein at the local level. They also play a very important role in the food webs of freshwater and saltwater organisms (Castellanos-Galindo et al 2011; Cooke et al 2016). The conservation of amphidromous fish is essential to ensure the sustainability of the unique freshwater species on islands around the world (Walter et al 2012). Water restoration and conservation planning are also important in various areas (Cooke et al 2016).

The results showed that all species in the Nike school in Gorontalo Bay had a negative allometric growth pattern ($b<3$), which indicates that the increase in length was faster than in body weight. The value of b for each species was lower compared to what was reported in FishBase. This was due to differences in the growth phases of the samples studied. The fish used in the FishBase were in the adult stage, while those in this study were in the post-larvae stage. The occurrence of two different life phases can cause changes in growth patterns (Froese 2006). Other factors that cause discrepancies include the number of specimens, size, population, diet, and overfishing (Pan et al 2015).

The inclusion of inland fisheries in the national policy has proven to be beneficial for encouraging economic and social growth, preventing further poverty, as well as encouraging the achievement of sustainable development goals (SDGs), especially those related to food security (Lynch et al 2017). Effective science-based management is very important and urgent for gobies with high economic potential (Gani et al 2020).

Conclusions. This study is one of the first to record the LWR of nine species of goby fry in Gorontalo Bay, Indonesia. All species exhibit a negative allometric growth pattern, indicating a more elongated body shape as they grow. This study contributes to Nike's future management and conservation planning.

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Conflict of Interest. The authors declare that there is no conflict of interest.

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