Yellowfin tuna population condition around the Fisheries Management Area 716, North Sulawesi, Indonesia

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Abstract. This study aims to describe the size composition, growth pattern, and fisheries of the yellowfin tuna (*Thunnus albacares*) population in the Fisheries Management Area 716, North Sulawesi. Samples were obtained from traditional fishermen who relied on handline fishing to get the tuna fish in this region, from 2017 to 2023. The fish were measured and weighed. These data were used to describe the size composition and the growth pattern. Data analyses were facilitated with MedCalc® Statistical Software version 22.014. Results showed that the individual size was dominated by size range of 120-140 cm fork length, whereas the fish population in this region has both negatively and allometric growth. Based on the individual size of the catch, handline fishing could be a reliable fishing method that can maintain the sustainable yellowfin stock in Indonesia waters, particularly in the fisheries Management Area of 716.

Key Words: growth pattern, handline fishing, size, sustainable stock.

Introduction. Yellowfin tuna is an economically important fish commercially exploited with an estimated annual global landing of 1.25 million metric tons in the last decade (Pecoraro et al 2017). Yellowfin tuna *Thunnus albacares* is included among the five fish species having the largest of global production volume (FAO 2022). Yellowfin tuna is one of the most exploited species and comprises one of the most profitable fisheries worldwide (Campling 2012). Yellowfin tuna is the highest export fisheries commodity from Indonesia after shrimps, prawns, and seaweed (Froese & Pauly 2023). High yellowfin tuna demands are caused by the presence of important chemical composition, such as fatty acid, amino acid, and minerals (Renuka et al 2017). This species has a high protein content (23.52%) and a low-fat content (1.93%), besides eighteen amino acids with a total amino acid of 84.49%, glutamic acid of 12.45%, and higher concentration of DHA (20.22% of total fatty acids) (Peng et al 2013). The high nutritional content of yellowfin tuna can be beneficial for health. This species inhabits the tropical and subtropical waters and is commonly found in the Atlantic, Pacific, and Indian oceans (ISSF 2021). Yellowfin tuna is a good swimming migratory fish (Olson et al 1996) and has the ability to maintain the high speed of swimming that makes the fish be able to spend a very short time to exploit food availability in the water, such as fish, cephalopods, and crustaceans. Increasing demands for tuna make the fishing effort to rise and their population be under fishing pressures. The small or immature individuals are taken as well and sold in local markets (Kantun & Amir 2013).

Yellowfin tuna is one of the tuna species relied by the hand-line fishermen to support their economic gain. Indonesian waters, especially Sulawesi Sea, hold high population of several tuna species, and hence there is a high number of tuna catches coming from this region. The Fisheries Management Area (FMA) 716 is located from the north of North Sulawesi to the northern islands bordering with the Philippines. This area has become a fishing spot for yellowfin tuna and other tuna species for both domestic and export needs.

As an important fishery commodity, the stock of the yellowfin tuna needs to be managed to allow the fish population to recover and be sustained through fishing pressure limitation based on the biological aspects, i.e., estimation of population parameters (Tangke et al 2022). The western and central Pacific Oceans treat yellowfin tuna as a single population for stock assessment, although there is a possibility of some intermingling between the eastern and western stocks (Miyake et al 2004), and therefore, Indonesian waters play important role for assessing stocks on the Indian and Pacific oceans (Hutubessy et al 2021). The population parameter analyses, such as asymptotic length, growth coefficient to mortality, recruitment pattern and spawning potential ratio (SPR) value, the utilization rate of yellowfin tuna in Ternate waters, North Mollucca, have revealed that the yellowfin tuna population is in an over exploited condition (Tangke et al 2024). According to The Law Number 45 of 2009, the Amendment to Law Number 31 of 2004 concerning fishery, fishery management is an integrated attempt to manage the information, analysis, planning, and decisions, as well as the allocation of fish resources and enforcement of law regulations in the field of fishery by the government to sustain the fish resources productivity and to achieve the agreed goals. For this, the balance of all fishery management aspects, including biological, environmental, economic and social aspects, should be maintained (Yunanda 2019). This study is aimed at describing the population condition of yellowfin tuna *Thunnus albacares* caught in WPP 716 based on biological aspects. These findings are expected to be able to provide beneficial information on the present tuna management strategy.

Material and Method. Data sampling used the Indonesia Fisheries Information System called I-Fish in order to inform the fisheries management planning at the regency, provincial, and national levels and to overcome the urgent needs for an effective and flexible data management platform in Indonesia by involving the fisheries industries. Tuna samples were obtained from hand-line fisheries around the Fisheries Management Area of 716 (Figure 1) from 2017 to 2023. The fish were caught by traditional fishermen using a vertical hand-line in the deep ocean, and then brought to the tuna fish collectors.

The tuna fish were measured directly on the field when the fishermen brought them to the fish collectors. The fish fork length (FL) was measured at 0.1 cm accuracy and the weight was recorded at 0.1 kg accuracy. These data were presented in a histogram to show the size structure of the population. The size composition data were also compared with those previously reported for different areas where the yellowfin tuna have been exploited to describe the stock condition of the yellowfin tuna in the FMA of 716. Information on yellowfin tuna size at first maturity was also collected through previous findings with different localities. Weight-length relationship was also calculated to describe the growth pattern of the population following Le Cren (1951):

$$W = aL^b$$

where: W = weight (g), L = length (cm), a and b = constants.

The aquation was changed to a linear regression by transforming the weight and length data into log^e values as: $Log^e W = log^e a + b \, log^e L$ to calculate b value. The growth pattern was obtained using the student's t-test on the observed b value at the confidence level of 95% (Zar 1984): b = 3 indicates an isometric growth, the length increment equals to the weight gain, b > 3 indicates positive allometric growth, the weight gain is faster than the length increment, and b < 3 indicates negative allometric growth, the length increases faster than weight development (Bagenal & Tesch 1978). Data analyses were facilitated with MedCalc® Statistical Software version 22.014 (MedCalc Software Ltd, Ostend, Belgium; https://www.medcalc.org; 2023).

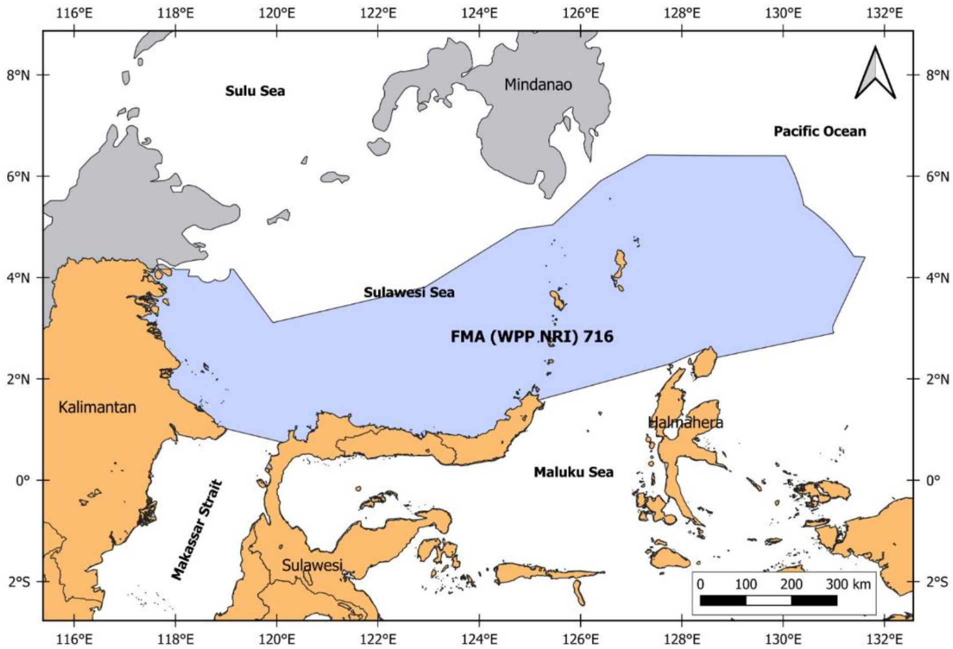

Figure 1. Tuna (*Thunnus* sp.) fishing ground in FMA 716.

Results and Discussion. The present study found 2094 individuals of yellowfin tuna and 24 individuals of *T. obesus* around the Fisheries Management Zone 716 from 2017 to 2023. Due to very low number of *T. obesus* catches, this species was not considered for further analysis. Figure 2 show that the most yellowfin tuna catches were dominated by a size range of 120-140 cm FL and body weight of 30-50 kg ind^{-1}.

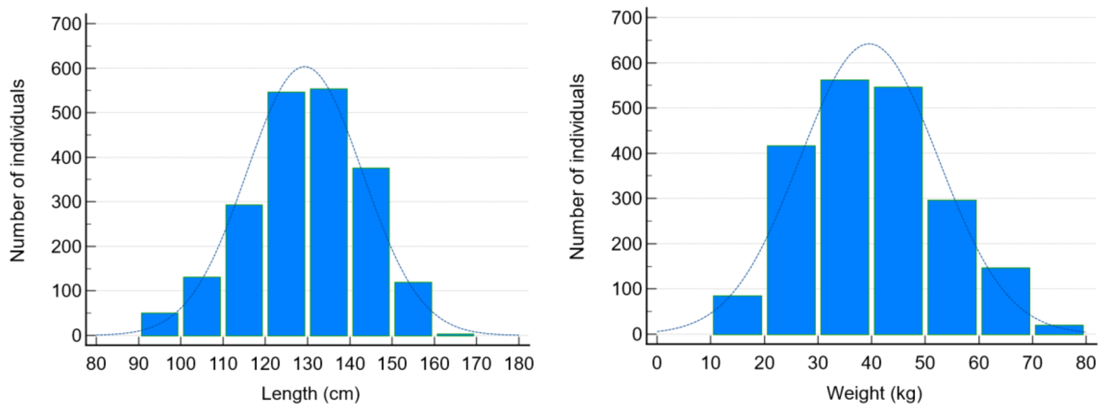

Figure 2. Length and weight frequency distribution of yellowfin tuna based on handliner's catches.

Yellowfin tuna can reach a maximum length of 239 cm FL (IGFA 2001) and maximum weight of 200 kg (Froes & Pauly 2024) with size at first maturity of 103.3 cm. Decrease in individual size could indicate a high fishing pressure and needs to be taken account for future stock management. Other previous studies from different places found the size at first maturity in the range of 85-119.6 cm FL (McPherson 1991; Timochina & Romanov 1991; Suzuki 1994; Rohit & Rammohan 2009; Hutubessy et al 2021; Shi et al 2022). This size composition of the catches in the FMA of 716, particularly in the present study, reflects that most caught yellowfin tunas were adult individuals and above the size at first maturity (Figure 2). It is in agreement with Froese (2004) that size composition of the catch should represent mature individuals, the highest catch of a cohort, and reflects the conservation of big-sized mature individuals. Therefore, handline fishing for yellowfin tuna is an environmentally friendly fishing tool and could be a reliable fishing method for future stock sustainability, especially tuna population. Nevertheless, yellowfin tuna is not only exploited by handline fishers. The catches, in fact, are also produced by purse seiners which commonly target small pelagic fishes and land a huge number of small-sized yellowfin tuna that are sold in the local market. They are usually caught by purse seiners around the fish raft. The same condition is also reported by Lehodey & Leroy (1999). So far, the deep-sea fish rafts are set to gather fish and then attract other fish species, such as tuna, skipjack, bonito, and others, feeding around the raft. However, large number of rafts are set on the migratory route of tuna and therefore have inhibited the regular tuna migration since they spend their time in this area for feeding, and are finally caught by the purse seiners.

Moreover, the weight-length relationship analysis of all data from 2017 to 2023 indicated that there is a strong correlation between individual weight and length, so the fish length can be used for weight prediction ($r^2 = 0.96$).

The slope test showed that the yellowfin tuna population in FMA 716 during 2017-2023 had an allometric growth (Figure 3). Figure 4 separately shows the weight-length relationships of yellowfin tuna from 2017 to 2023. All regressions reflect that the fish length could be used to predict the fish weight. The slope test found the b values of 2.86-3.2 meaning that during the study period, the yellowfin tuna has either negative or positive allometric growth reflecting the fluctuations of the yellowfin tuna population conditions with time.

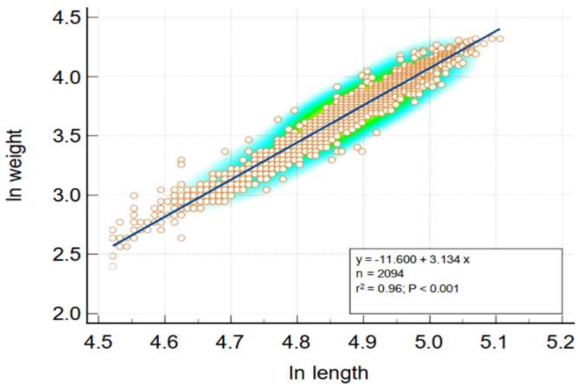

Figure 3. Weight-length relationship of yellowfin tuna from FMA 716.

Zhu et al (2010) reported that bigeye tuna (*T. obesus*), yellowfin tuna (*T. albacares*), and albacore (*T. alalunga*) had an allometric growth in the Atlantic, Indian, and Pacific Oceans. Several previous studies in different parts of Indonesia showed both negatively allometric growth (Nugroho et al (2018) in Simeulue, Aceh Province, Jalil et al (2020) in Bone bay, Ghofar et al (2021) in in the Fisheries Management Area 573 of Indian Ocean, Kalor et al (2022) in Demta waters, Papua, Patanda et al (2022) in PPN Pelabuhanratu, Sukabumi), isometric growth (Syamsinar et al 2023), and positive allometric growth in the eastern Pacific Ocean (Thierry et al 2021). According to Canosa & Bertucci (2023), growth is influenced by biotic factors, such as nutrition, feeding, and reproductive regulating hormone, and abiotic factors, such as temperature, oxygen level, and salinity. Global climate change and anthropogenic pollutants can also modify the environmental conditions that directly or indirectly influence the growth performance.

Yellowfin tuna belongs to fish group having very high rates of digestion (Brill 1996), in which the fish must be able to fully exploit a food patch wherever one is found. Also, because the pelagic environment makes tuna have no place to hide and rest, their high sustainable swimming speeds help to rapidly repay an oxygen debt which also results in rapid growth rates and high fecundity (Brill 1987; Schaefer 1996). However, the availability of food, in quality and quantity, is important to support animal growth. Therefore, difference in growth patterns with time could result from food prey availability controlled by the environmental conditions so that the same fish species can have either isometric or allometric growth. Despite data collection limitation of yellowfin tuna from FMA 716, particularly in the present study, the findings have presented a beneficial information concerning the tuna population condition in this area for future research development.

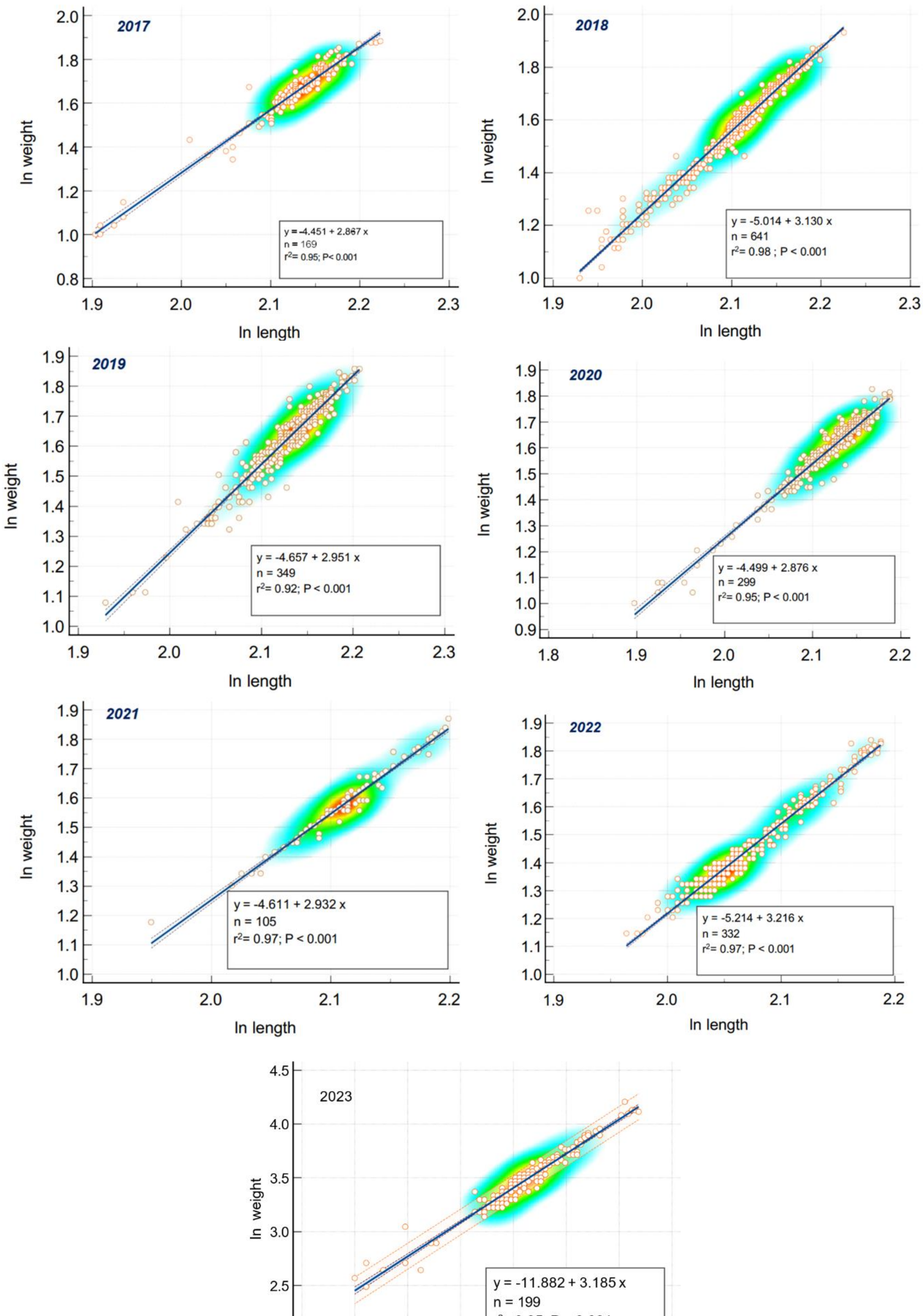

Figure 4. Weight-length relationship of *T. albacares* with year.

Conclusions. Yellowfin tuna *T. albacares* caught in the FMA 716 by the handline fishers were dominated by legal size individuals reflecting an environmentally friendly exploitation. The fish population had negative and positive allometric growth depending upon localities which could be caused by food prey availability fluctuations in the ocean. More intensive data collection is also required to possibly yield a better and sustainable exploitation strategy.

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

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