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GROWTH PATTERN OF BIGFIN REEF SQUID (*Sepioteuthis lessoniana*) IN KOLAKA WATERS, SOUTHEAST SULAWESI

Pola Pertumbuhan Cumi - Cumi Sirip Besar (*Sepioteuthis lessoniana*) di Perairan Kolaka, Sulawesi Tenggara

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ABSTRACT

Length–weight relationships using the allometric model $W=aL^b$ are widely applied to describe growth patterns in aquatic organisms. This study analyzed the length-weight relationship of bigfin reef squid (*Sepioteuthis lessoniana*) in Kolaka Waters, Southeast Sulawesi. Samples were randomly collected from fishermen's catches in Tanggetada District during July–December 2025, with measurements of total length, mantle length, and body weight. The results showed that the population size structure was dominated by medium to large sized individuals. The length–weight relationship yielded a growth coefficient b<3, indicating a negative allometric growth pattern, where length increases faster than body weight. Although the allometric model effectively describes general growth patterns, its application across the entire size range should be treated with caution due to potential bias, particularly at extreme sizes. These findings provide important biological information to support the sustainable management of S. lessoniana in Kolaka Water.

Keywords: Kolaka Waters, Length–Weight Relationship, Negative Allometry, Sepioteuthis lessoniana

ABSTRAK

Hubungan panjang–berat dengan model allometrik $W=aL^b$ umum digunakan untuk menggambarkan pola pertumbuhan organisme perairan. Penelitian ini menganalisis hubungan panjang–berat cumi-cumi sirip besar (*Sepioteuthis lessoniana*) di Perairan Kolaka, Sulawesi Tenggara. Sampel dikumpulkan secara acak dari hasil tangkapan nelayan di Kecamatan Tanggetada selama Juli-Desember 2025, dengan pengukuran panjang total tubuh, panjang mantel, dan berat tubuh. Hasil menunjukkan bahwa struktur ukuran populasi didominasi individu berukuran menengah hingga besar. Hubungan panjang–berat menghasilkan koefisien pertumbuhan $b<3$, yang mengindikasikan pola pertumbuhan allometrik negatif, di mana pertambahan panjang lebih cepat dibandingkan pertambahan berat. Meskipun model allometrik efektif menggambarkan pola pertumbuhan secara umum, penerapannya pada seluruh rentang

ukuran perlu dilakukan secara hati-hati karena potensi bias, terutama pada ukuran ekstrem. Temuan ini memberikan dasar biologis penting bagi pengelolaan *S. lessoniana* secara berkelanjutan di Perairan Kolaka.

Kata Kunci: Allometrik Negatif, Hubungan Panjang–Berat, Perairan Kolaka, *Sepioteuthis lessoniana*

INTRODUCTION

The bigfin squid (*Sepioteuthis lessoniana*) is a cephalopod species widely distributed in tropical Indo-Pacific waters and plays a crucial ecological role in marine ecosystems (Coll et al., 2013). This species contributes to nutrient cycling, energy flow, and maintains the balance of marine food webs (Chesnais et al., 2019), while demonstrating high adaptability to changing environmental conditions (Pecl & Jackson, 2008).

In addition to its ecological role, *S. lessoniana* also has high economic value and is an important commodity in coastal fisheries, particularly as a primary target for small-scale fisheries in various regions of Indonesia (Arkhipkin et al., 2015; Ernaningsih et al., 2019). The increasing market demand for this commodity is in line with the squid's biological characteristics, which have a relatively short life cycle and rapid growth rate. These conditions require resource management based on accurate and reliable biological information to ensure sustainable utilization (Hilborn et al., 2019).

Growth patterns are a fundamental biological aspect of fisheries resource management because they provide crucial information on population dynamics, physiological conditions, and a basis for stock assessments to support sustainable fisheries management (Julius et al., 2025). Analysis of the length-weight relationship can provide insight into the growth characteristics (Ding et al., 2025), physiological conditions, and population status of a species in specific waters and has been widely used in fisheries biology studies (Deekrachang et al., 2024).

In *S. lessoniana*, differences in growth patterns between regions have been reported, reflecting variations in environmental conditions, food availability, and differences in population structure across water locations (Sivashanthini et al., 2009; Önsoy & Salman, 2022). Therefore, site-specific growth studies are crucial for a more accurate understanding of population dynamics and as a basis for developing resource management strategies tailored to local water characteristics (Hilborn et al., 2019).

The waters of Kolaka, Southeast Sulawesi, particularly the fishing grounds in Tanggetada District, are one of the areas with quite intensive bigfin squid fishing activity. However, scientific information on the growth aspects of S. lessoniana in this area remains limited compared to other waters in Indonesia. Therefore, this study aims to analyze the growth patterns of bigfin squid (*Sepioteuthis lessoniana*) in Kolaka waters using a length-weight relationship approach. The results of this study are expected to provide basic biological information needed as a reference for the sustainable management and utilization of bigfin squid resources in Southeast Sulawesi.

METHODS

Research Location and Time

This research was conducted in Kolaka Waters, Southeast Sulawesi, with sampling focused on Tanggetada District, one of the primary fishing grounds for bigfin squid (*Sepioteuthis lessoniana*). Sampling took place during July–December 2025, encompassing the dry and transitional seasons.

Sampling

Bigfin squid (*Sepioteuthis lessoniana*) samples were obtained from the daily catch of local fishermen using traditional fishing gear such as squid jigs and gillnets. Sampling was conducted using a simple random sampling method from the landings to minimize size selectivity bias. All samples were stored in insulated containers with ice and immediately transported to the laboratory for morphometric measurements, in accordance with general sampling procedures in fisheries biology studies (Ningsih et al., 2023; Asriani et al., 2025).

Morphometric Measurements

Each squid individual was measured for morphometric parameters, including mantle length (ML), total length (TL), and body weight (W). Mantle length was measured from the anterior to the posterior tip of the mantle, while total length was measured from the tip of the longest arm to the posterior tip of the mantle using a measuring board with an accuracy of 1 mm. Body weight was measured using a digital scale with an accuracy of 0.01 g. These parameter measurements followed standard procedures used in cephalopod morphometric studies to ensure consistency and comparability of data between studies (Ervinia et al., 2024). All measurement data were recorded individually and tabulated for further statistical analysis.

Length Frequency Analysis

The length frequency distribution of bigfin squid (*S. lessoniana*) was analyzed based on total length (TL) data obtained from all sampled individuals. Length data were grouped into length classes at specific intervals to illustrate the distribution of individual sizes within the population. Length class intervals were determined by considering the size range and sample size to ensure the resulting distribution is representative and accurately reflects population structure (Froese et al., 2018). Length frequencies are presented in histograms to identify population size structure and the dominance of specific size classes within the population. Length-frequency distribution analysis is a common and effective approach used in studies of fisheries biology and soft-bodied marine organisms such as cephalopods to evaluate size dynamics, recruitment patterns, and fishing pressure (Zhou et al., 2022). The information obtained from this analysis serves as a basis for understanding population characteristics and the conditions of resource utilization of S. lessoniana in Kolaka Waters.

Growth Pattern Analysis

The growth pattern of *S. lessoniana* was analyzed through the length-weight relationship using the allometric equation $W=aL^b$, where W is body weight, L is body length or mantle length, a is a constant, and b is the growth coefficient (Sivashanthini et al., 2009). This equation is usually transformed into the form Log W = log a + b log L for linear regression analysis (Andy Omar et al., 2020). The coefficient b value is used to interpret growth patterns; isometric if $b = 3$, positive allometric if $b > 3$, and negative allometric if $b < 3$. The coefficient of determination (R^2) is used to evaluate the strength of the length-weight relationship (Zar, 2010; Önsoy & Salman, 2022).

Data Analysis and Presentation

Data analysis was performed statistically to evaluate the length-weight relationship of *S. lessoniana* using linear regression on logarithmically transformed data. The results of the analysis are presented in the form of a length-weight relationship graph accompanied by the regression equation and coefficient of determination (R^2) value (Önsoy & Salman, 2022), and are explained descriptively to illustrate the growth characteristics of *S. lessoniana*.

RESULTS

The length distribution results for *S. lessoniana* can be seen in Figure 1.

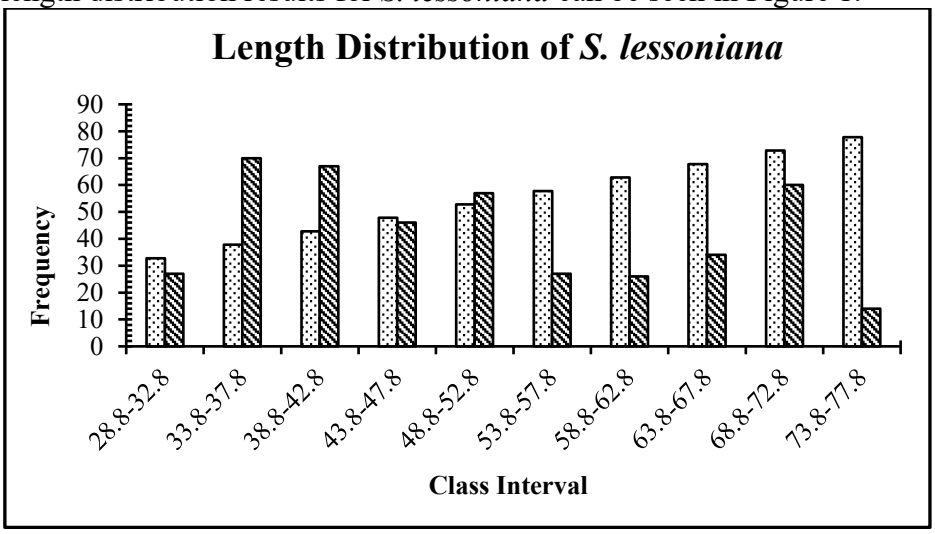

Figure 1. Body Length Distribution of *Sepioteuthis lessoniana*
Information: Class Interval ⬚ Frequency ▨

The results of the length-weight relationship analysis for *S. lessoniana* can be seen in Figure 2.

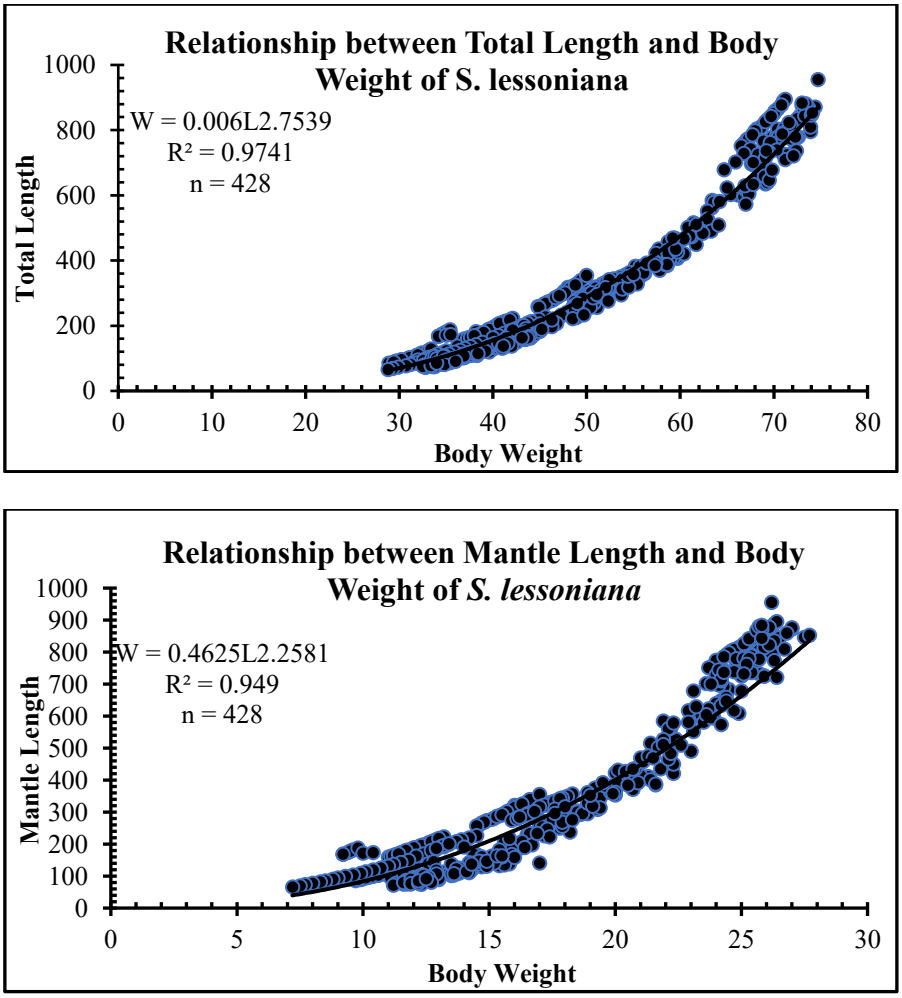

Figure 2. Length-Weight Relationship for *Sepioteuthis lessoniana*

DISCUSSION

Size Distribution

The total body length distribution of bigfin squid (*Sepioteuthis lessoniana*) in this study showed wide size variation, ranging from 28.8 to 77.8 mm (Figure 1). The frequency of small individuals was relatively low, then increased in the medium size class, which dominated the population between 33.8–37.8 mm and 52.8 mm. In the larger size classes (53.8–57.8 mm to 63.8–67.8 mm), the frequency of individuals remained relatively stable, with the highest frequency recorded in the large size class, particularly between 68.8–72.8 mm and 73.8–77.8 mm. This indicates that the catch was dominated by medium- to large-sized individuals or individuals that had entered the subadult to adult stages.

The increasing size distribution pattern toward the large size class is thought to be influenced by gear selectivity and aquatic environmental conditions that favor the growth and survival of *S. lessoniana*. Similar patterns have been reported in various other tropical waters. A study in the Spermonde Islands showed a wide range of body sizes and a population structure dominated by commercial-sized individuals (Ernaningsih et al., 2019). Furthermore, a study in the waters of Langkawi Island, Malaysia, through size frequency and length-weight relationship analyses, reported a dominance of medium- to large-sized individuals with a negative allometric growth pattern (Rohizad et al., 2024). Age and growth studies in the Gulf of Mannar also showed wide body size variation and the presence of multiple cohorts within the *S. lessoniana* population, reflecting uneven growth and recruitment dynamics (Kavitha et al., 2024).

Growth Pattern

The results of the length-weight relationship analysis of bigfin squid (S. lessoniana) in Kolaka waters showed a growth coefficient (b) value less than 3 ($b < 3$), indicating a negative allometric growth pattern (Figure 2). This pattern indicates that body length increases more rapidly than weight increases as individual size increases. The relatively high coefficient of determination (R^2) value indicates a strong relationship between total length or mantle length and body weight, so that the regression model used is able to explain variations in body weight adequately.

The negative allometric growth pattern in *S. lessoniana* indicates that body length increases faster than weight, reflecting a typical cephalopod growth strategy, particularly during the active growth phase. The reported growth coefficient ($b < 3$) for the length–weight relationship in *S. lessoniana* indicates that growth energy is allocated more to the development of body structures such as the mantle and arms than to the proportional accumulation of body mass. This strategy is common in loliginids and is associated with functional needs to improve swimming performance and mobility (Semmens & Moltschaniwskyj, 2000). The relatively dominant growth of the mantle plays a crucial role in increasing movement capacity (jet propulsion), thus supporting efficient foraging and predator avoidance (Zeidberg, 2004). Furthermore, studies of cephalopod energetics indicate that energy allocation in the early life phase is directed more toward the development of body structures that support locomotor activity and predation, rather than increasing biomass, as an adaptation to environmental pressures and high predation risk (Kooijman & Augustine, 2022). Thus, negative allometric growth in *S. lessoniana* can be viewed as an adaptive strategy that optimizes the ecological function and survival of this species in coastal water habitats.

Based on the sampling period, the observed growth pattern is likely influenced by seasonal variations in environmental conditions in Kolaka Waters. The July–September period coincides with the dry season, which is generally characterized by relatively stable waters, low turbidity levels, and relatively high food availability due to increased primary productivity. These conditions support rapid body length growth in squid, particularly in juveniles.

Conversely, the October–December period is a transitional phase leading to the rainy season, characterized by increased rainfall, salinity fluctuations, and changes in coastal water dynamics. These changes in environmental conditions may affect energy allocation patterns in *S. lessoniana*, with some energy being diverted to physiological maintenance and reproductive preparation, particularly in larger individuals. This could potentially lead to body weight gain disproportionate to length gain, thus reinforcing the negative allometric pattern identified in this study.

The results of this study are consistent with previous findings showing that the growth pattern of *S. lessoniana* is dynamic and can vary temporally, particularly in relation to seasonal factors and the life cycle. Although this study did not directly observe the level of gonadal maturity, variations in the growth coefficient (b) values in the length-weight relationship obtained are likely related to changes in energy allocation during the reproductive phase, as has been reported in various cephalopod studies. In loliginids, the seasonal process of gonadal maturation can cause a diversion of energy from somatic growth to reproductive tissue development, resulting in an increase in body weight that is not always proportional to the increase in mantle length, or conversely, a restraint in weight growth despite continued increase in body length (Semmens & Moltschaniwskyj, 2000). Recent studies also indicate that gonadal development in *S. lessoniana* is influenced by environmental factors such as water temperature, which can potentially trigger fluctuations in physiological conditions and growth patterns throughout the year (Kubo et al., 2025). Furthermore, the presence of multiple seasonal cohorts and distinct spawning peaks has been reported in this species, suggesting that growth parameters may change over time in response to heterogeneous reproductive strategies (Kavitha et al., 2024). Therefore, the variation in b coefficient values observed in this study likely reflects physiological responses to seasonal and reproductive dynamics, although direct testing of this relationship requires integration of gonadal maturity data in future studies.

Furthermore, the sample size structure, dominated by medium- to large-sized *S. lessoniana* individuals, indicates a predominance of subadult to adult stages in the catch. During this phase, somatic growth rates tend to slow due to a shift in energy allocation from growth to other physiological processes, including reproductive activity. Although gonadal maturity was not directly observed, other studies have shown that *S. lessoniana* reproductive dynamics are influenced by environmental factors such as water temperature, which can trigger temporal variations in physiological and growth patterns. Furthermore, the selectivity of fishing gear has the potential to reduce the representation of small individuals, thus affecting the estimation of growth parameters based on the length-weight relationship (Ernaningsih et al., 2019; Ching et al., 2024).

Although the allometric model $W=aL^b$ is widely used to describe growth patterns and estimate biomass, its application across a wide range of sizes and seasonal periods requires caution. Several studies have shown that length–weight relationship parameters can vary seasonally and interannually in response to changes in environmental conditions and population structure, potentially introducing bias, particularly at extreme sizes (Orduna et al. 2023; Hebert et al. 2025). This variability indicates that the assumption of a constant length–weight relationship over time is not always valid. Therefore, in the context of fisheries management, the application of additional approaches such as seasonal growth analysis, size-class grouping, or calculating the average weight within each length class is recommended to improve the accuracy of biomass estimates and assess population health. Overall, the negative allometric growth pattern of *S. lessoniana* in Kolaka Waters not only reflects the biological characteristics of the species but also indicates the influence of seasonal environmental conditions on growth dynamics. This information provides an important scientific basis for adaptive and sustainable management of bigfin squid fisheries, taking into account seasonal variations in resource utilization strategies.

CONCLUSION

The population of bigfin squid (*Sepioteuthis lessoniana*) in Kolaka Waters is dominated by medium to large-sized individuals, indicating a population structure from the subadult to adult phases. The length-weight relationship shows a negative allometric growth pattern ($b < 3$), where body length increases faster than weight. This growth pattern reflects the species' biological strategy and is influenced by seasonal environmental dynamics. These findings provide important baseline information for stock assessment and sustainable fisheries management of *S. lessoniana*.

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