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Morphometric and Length–Weight Relationship of Sea Cucumbers (Holothuriidae) in Northern Waters of Tunda Island, Banten

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ABSTRACT

Sea cucumbers (family *Holothuriidae*) are economically important marine invertebrates that are increasingly exploited, raising concerns about the sustainability of their populations. Sea cucumbers are economically valuable and contain bioactive compounds, making them important fisheries resources. This study aimed to analyze the morphometrics and length–weight relationship of sea cucumbers in the northern waters of Tunda Island, Banten. Sampling was conducted on 20–21 September 2025 using hand picking within 50 × 50 cm transects, with a total of 18 individuals collected. Morphometric parameters, including body length, diameter, and Body Basal Area (BBA), were measured under in situ and ex situ conditions. Linear regression analyses were performed to determine the relationships between these parameters and body weight. Results showed that BBA was the most reliable predictor of body weight, with R^2 = 0.731 for ex situ measurements, while in situ measurements had higher variability (R^2 = 0.219). Diameter and length had lower predictive power. These findings provide baseline data for sustainable management and utilization of sea cucumber populations. Future studies should integrate physiological variables, seasonal variation, and image-based morphometrics to enhance biomass estimation and conservation strategies.

INTRODUCTION

Marine Sea cucumbers (class Holothuroidea) are economically important marine resources that are increasingly exploited, raising concerns about the sustainability of their populations in many coastal areas. Globally, the exploitation of marine resources has continued to increase, including the utilization of marine invertebrates, which has gained growing attention over recent decades. One marine invertebrate with high economic value is the sea cucumber (Pramithasari et al., 2024). Sea cucumbers belong to the class Holothuroidea and are recognized for their potential as a source of animal protein and bioactive compounds, making them an important fisheries commodity.

The increasing utilization of sea cucumbers needs to be accompanied by sustainable management, which requires an understanding of their biological characteristics and growth patterns. One commonly used approach in fisheries biology is morphometric analysis, particularly the length–weight relationship. This parameter is widely applied in stock assessment, biomass estimation, and the evaluation of growth conditions, as it reflects organism responses to environmental conditions under both in situ and ex situ contexts (Bayu Setyadi et al., 2018). Therefore, length–weight relationships provide an essential scientific basis for sustainable fisheries resource management, including sea cucumbers.

Tunda Island is a coastal area in Serang Regency, Banten, known for its high potential of coastal and marine biological resources (Legowo et al., 2019; Ulumi & Syafar, 2021) and as a national sport fishing location (Sasongko, 2020). Fishing activities in this area have been reported to produce Holothuroidea as bycatch and indicate increasing exploitation pressure that may be unsustainable, potentially leading to a decline in sea cucumber populations. However, scientific information regarding the length–weight relationship of sea cucumbers in the northern waters of Tunda Island, Banten, remains very limited, particularly in terms of location-specific biological data.

Although length–weight relationships of sea cucumbers have been widely used as important biological parameters in stock and biomass assessments, their application in the northern waters of Tunda Island has not been reported. This condition indicates a research gap related to the availability of site-specific biological information required to support sustainable sea cucumber management. The novelty of this study lies in providing baseline data on the length–weight relationship of sea cucumbers from the northern waters of Tunda Island, Banten. Therefore, this study aims to analyze the length–weight relationship of sea cucumbers in the northern waters of Tunda Island, Banten, to support sustainable fisheries management and utilization, particularly of sea cucumber resources.

METHOD

This study was conducted on 20–21 September 2025 in the northern waters of Tunda Island, Wargasara Village, Tirtayasa District, Serang, Banten Province. The study area was characterized by rubble substrates of coral fragments, coarse sand, and patches of seagrass, which commonly serve as habitats for various sea cucumber species (Figure 1).

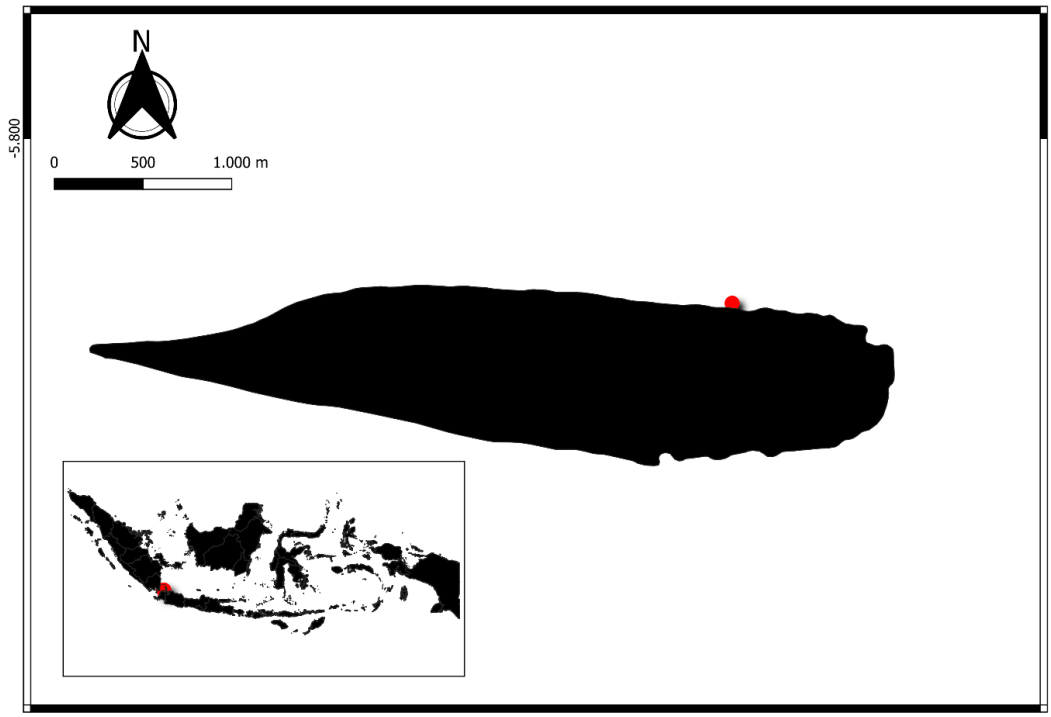

Figure 1. Map of the study area showing the sampling location in northern waters of Tunda Island, Banten

Sampling was conducted using an incidental sampling approach with a hand-picking technique under in situ conditions. Each encountered individual was sampled within a 50 × 50 cm transect plot, resulting in a total of 18 sampling units corresponding to 18 individuals. Within each transect, sea cucumber body length was measured using a ruler, while body diameter was measured using a caliper. The same individuals were subsequently measured

under ex situ conditions using similar procedures, with additional measurements of body weight conducted using a digital balance. This dual measurement approach was applied to compare the consistency of morphometric parameters between in situ and ex situ conditions (Figure 2).

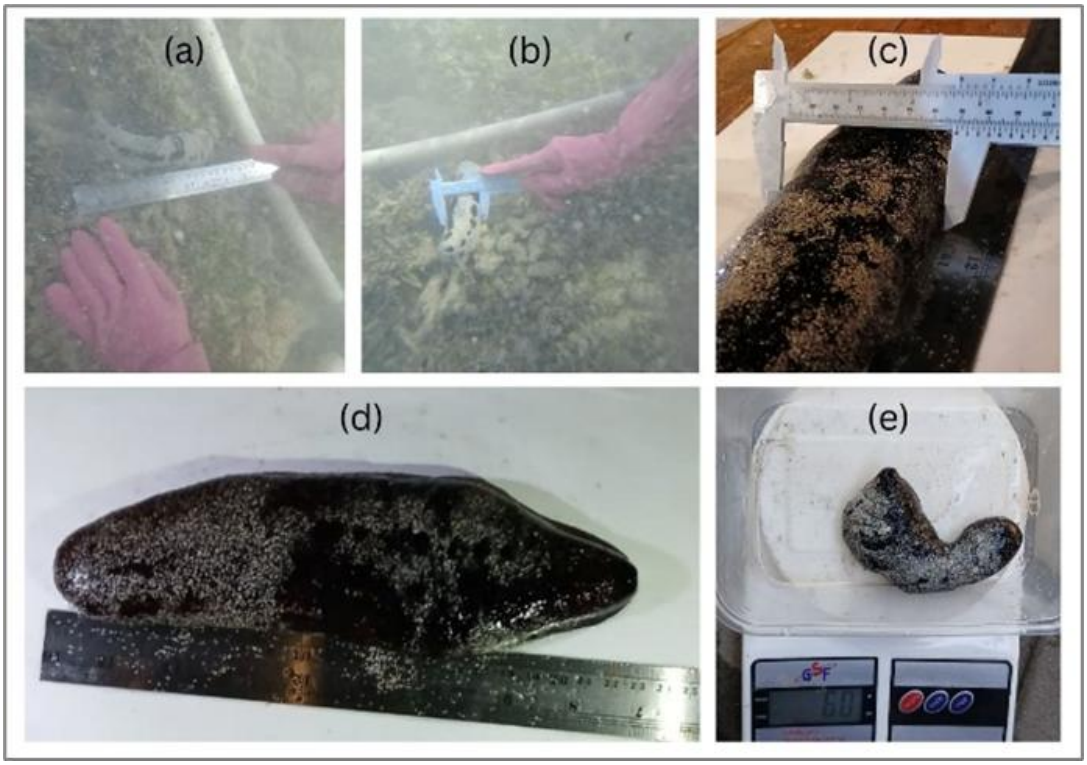

Figure 2. Length–weight analysis of sea cucumbers under in situ and ex situ conditions: (a) body length measurement in situ; (b) body diameter measurement in situ; (c) body diameter measurement ex situ; (d) body length measurement ex situ; and (e) body weight measurement ex situ

The morphometric parameters obtained included body length, body diameter, and body basal area (BBA). Body basal area was calculated to represent the cross-sectional size of the sea cucumber body, assuming an elliptical shape, using the following formula:

$$Body\ basal\ area\ (BBA) = \pi \times \left(\frac{L}{2}\right) \times \left(\frac{W}{2}\right)$$

where L represents body length and W represents body diameter (Purcell et al., 2025).

All morphometric parameters were analyzed using linear regression to determine the length–weight relationship (Magwa et al., 2023). The analyses were performed in R Studio for body basal area (BBA) versus body weight, body diameter versus body weight, and body length versus body weight. This approach was applied to evaluate growth patterns, the suitability of body parameters relative to body weight, and differences in measurement performance between in situ and ex situ conditions.

RESULT AND DISCUSSION

Table 1. Morphometric measurements of sea cucumbers (length, diameter, body weight, and body basal area) collected from the northern waters of Tunda Island, Banten

Code	Length (cm)	Diameter (cm)	Weight (g)	BBA (cm^2)
N01	30	59	678	13.89
N02	23	77	306	13.9

Code	Length (cm)	Diameter (cm)	Weight (g)	BBA (cm^2)
N03	16	26	276	3.16
N04	21	47	163	7.75
N05	18	21	164	2.88
N06	16	60	324	7.54
N07	23	35	293	6.32
N08	21	33	176	5.44
N09	20	20	36	2.99
N10	29	27	50	6.15
N11	18	37	189	5.23
N12	19	41	153	6.12
N13	13	25	663	2.55
N14	18	39	187	5.51
N15	15	58	273	6.83
N16	11	32	239	2.76
N17	14	53	60	5.82
N18	8	26	242	1.63

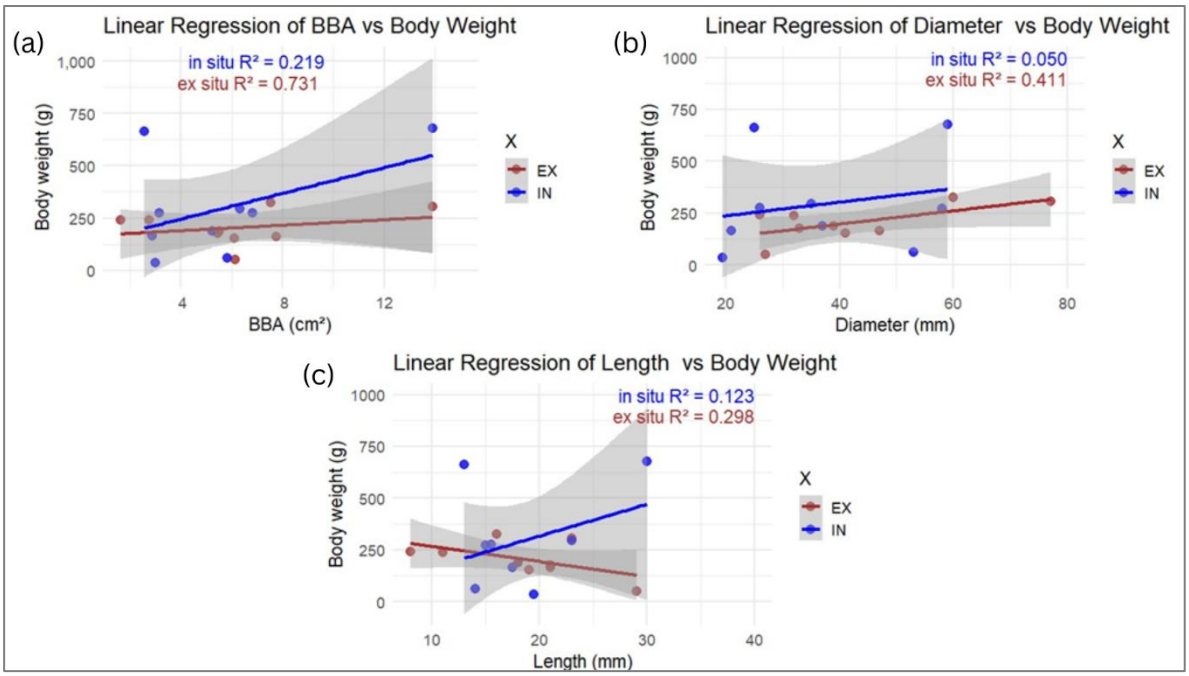

Figure 3. Linear regression of sea cucumber morphometric parameters against body weight using R Studio. (a) Body Basal Area (BBA) vs. body weight; (b) Diameter vs. body weight; (c) Length vs. body weight. Measurements were conducted under in situ and ex situ conditions

The morphometric parameters of all sampled sea cucumbers are summarized in Table 1, and the results of linear regression analyses are shown in Figure 3. Overall, the relationships between morphometric parameters and body weight varied clearly between in situ and ex situ measurements. Body Basal Area (BBA) showed the highest coefficient of determination in ex situ measurements (R^2 = 0.731), indicating that BBA is the most reliable biometric predictor of body weight under controlled measurement conditions. In ex situ conditions, sea cucumber bodies experienced water loss, becoming flatter and wider, which stabilized the basal area and allowed more consistent measurements. In contrast, BBA measured in situ yielded a lower R^2

(0.219), suggesting that natural habitat conditions, water interaction, and physiological status contributed to higher variability in measurements.

Diameter and length exhibited similar patterns, although their coefficients of determination were lower than BBA. For diameter versus body weight, R^2 reached 0.411 in ex situ measurements and only 0.050 in situ, indicating that diameter is less reliable for predicting weight in natural conditions due to body flexibility and susceptibility to contraction and hydrodynamic pressure. Similarly, length versus body weight yielded R^2 values of 0.123 in situ and 0.298 ex situ, showing that body length alone is not a strong predictor of weight because of the sea cucumber's elastic morphology. These results demonstrate that measurement media directly affect morphometric accuracy, as ex situ measurements provide greater dimensional stability while in situ measurements reflect the natural variability of sea cucumber shape.

The findings are consistent with previous studies showing that two-dimensional morphometric parameters, such as basal area or square-root length–width (SLW), often predict weight more accurately than linear length alone (Hammond & Purcell, 2024). The elastic and contractile nature of Holothuroidea explains why body length is often unstable as a biomass indicator (Panuluh et al., 2019; Rasyadi et al., 2023). Some studies, however, reported contrasting patterns; Djenidi et al. (2024) found that in situ measurements in Holothuria lessoni produced stronger size–weight relationships than ex situ, highlighting the species-, habitat-, and method-specific nature of morphometric relationships. Research in Sri Lanka also reported significant differences in length–weight relationships among species and locations, showing negative allometric growth in some populations (Veronika et al., 2018). These comparisons reinforce that morphometric–weight relationships in sea cucumbers are not universal and should be interpreted in context.

The higher accuracy of ex situ measurements indicates that BBA is a more stable predictor of weight, particularly in species with high body plasticity. Accurate morphometric measurements are essential for developing valid length–weight relationships (LWR), which are fundamental for biomass assessment, stock estimation, and sustainable fisheries management (Ahmed et al., 2018; Setyastuti et al., 2024). Fluctuations in in situ measurements underline the importance of correcting raw field data to avoid over- or underestimation of population biomass, especially for economically valuable species (Dereli & Aydın, 2021).

The findings also have important implications for sea cucumber management. Area-based morphometric parameters are more stable than single linear measurements for flexible-bodied organisms. This agrees with Djenidi et al. (2024), who reported higher precision in weight estimation using area-based parameters in Holothuria lessoni, and with Hammond and Purcell (2024), who confirmed that body length alone is insufficient for biomass estimation in Pearsonothuria graeffei due to variability in in situ measurements. Variation in R^2 between measurement methods emphasizes that measurement conditions strongly affect body shape and parameter reliability. While ex situ measurements offer controlled conditions, in situ data remain critical for field-based population assessments.

Spatial variability in sea cucumber growth observed in this study is consistent with other studies. Rasyadi et al. (2023) demonstrated environmental and substrate effects on Holothuria scabra length–weight relationships in Lombok, and Veronika et al. (2018) reported significant interspecies differences in Sri Lanka. These findings highlight the need for site-specific morphometric models, such as the one developed for Tunda Island in this study.

Despite these insights, this study has limitations. Physiological variables such as gonad condition, gut fullness, and hydration levels were not evaluated, yet they can affect body weight and allometric patterns (Purcell, 2021). Measurements were also restricted to a single location and sampling period, limiting generalizability. Prior studies show that allometric parameters can differ significantly between species and habitats (Veronika et al., 2018; Rasyadi et al., 2023), highlighting the importance of local calibration for LWR equations. Future research should incorporate physiological factors and non-invasive approaches, such as image-based morphometrics, and extend measurements across seasons. Integrating in situ, ex situ, and digital imaging data will improve conversion models, providing more robust and accurate stock

assessments to support sustainable sea cucumber management in Tunda Island and other coastal areas (McGeady et al., 2023; Setyastuti et al., 2024).

CONCLUSION

The morphometric analysis of sea cucumbers in the northern waters of Tunda Island, Banten, demonstrated that Body Basal Area (BBA) showed a relatively stronger relationship with body weight compared to other morphometric parameters, with a coefficient of determination (R^2) of 0.731 under ex situ conditions and 0.219 under in situ conditions. Ex situ measurements provided higher stability and stronger correlations, while in situ measurements were influenced by physiological and environmental variability. Diameter and length showed lower predictive power, emphasizing the importance of selecting appropriate morphometric parameters for biomass estimation.

These findings provide essential baseline data for sustainable management and utilization of sea cucumber populations in Tunda Island. Future research should integrate physiological variables, seasonal variation, and image-based morphometrics to enhance prediction accuracy and support conservation strategies.

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