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Biometric Characterization and Sexual Dimorphism in 10 Demersal Fish Species From Southern São Tomé and Príncipe

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ABSTRACT

This study examines key biometric parameters—length–weight relationships (LWRs), sex ratios, and Fulton's condition factor (*K*)—for 10 demersal fish species in the coastal waters of southern São Tomé Island: *Dentex macrophthalmus*, *Dentex congoensis*, *Pagrus caeruleostictus*, *Lethrinus atlanticus*, *Lutjanus fulgens*, *Lutjanus goreensis*, *Lutjanus agennes*, *Apsilus fuscus*, *Pomadasys rogerii*, and *Paranthias furcifer*. The samples were collected by artisanal fishers from March 2019 to February 2020 across eight nearshore sites. Fishing occurred regularly using handlines, including horizontal and vertical longlines and single-hook artificial lures. A total of 1417 individuals were analysed. LWR slopes (*b*) ranged from 2.122 to 3.515, with negative allometry observed in most cases. Significant sex-based differences in growth patterns were detected in several species. Sex ratio analysis revealed male-biased populations in *D. macrophthalmus*, *P. rogerii*, and *P. furcifer*, and female-biased populations in *D. congoensis*, *L. fulgens*, and *L. goreensis*. Condition factor values ranged from 0.468 to 1.525, with notably low *K* values in *A. fuscus*, suggesting poorer body condition. This study provides the first baseline data for LWRs, sex ratios, and condition factors for these species in São Tomé and Príncipe and reports a new maximum body length for *P. furcifer*. The findings offer critical input for future stock assessments and evidence-based fisheries management in the region.

1 | Introduction

Fish is an important source of high-quality protein and a key contributor to global food security (Wang et al. 2024). However, fish populations are under increasing pressure from overfishing and environmental changes, extending beyond the effects of pollution alone (Coll et al. 2010; Jisr et al. 2018). Fisheries support the economies of coastal communities, particularly in developing nations, by providing employment, livelihoods, and sustenance. Despite international conservation efforts to protect marine ecosystems and fish biodiversity, fishery productivity continues to decline in many regions (EDF 2023; Palomares et al. 2020).

Sustainable fisheries management relies on reliable fish stock assessments, yet data limitations often hinder effective decision-making. Biometric studies, which provide key information for estimating fish biomass, play a central role in fisheries research and resource monitoring (Jisr et al. 2018). Among these, the length–weight relationship (LWR) is widely used to analyse species growth patterns, condition, and morphological variations (Wang et al. 2024). LWR metrics are particularly valuable in data-limited fisheries, where they support stock assessments by estimating biomass and population structure in the absence of direct age-based data (Froese 2006; Jurado-Ruzafa and Hernández-González 2024). Integrating sex ratio information further enhances these assessments by accounting for sex-specific growth patterns, differential mortality, and reproductive potential, all of which influence population dynamics and sustainability. Since many fish species exhibit sexual dimorphism or are subject to selective fishing pressure, monitoring sex ratios is essential for detecting imbalances that could affect recruitment and long-term stock viability (Cheng et al. 2025). Additionally, these biometric studies provide insights into spatiotemporal variations in fish condition and enable comparisons of life-history traits across different geographic regions (Jurado-Ruzafa and Hernández-González 2024).

The Democratic Republic of São Tomé and Príncipe is an island nation located in the Gulf of Guinea, West Africa, approximately 255 to 220 km from the mainland. It comprises two main islands, São Tomé and Príncipe, with areas of 859 and 142 km^2, respectively (Porriños et al. 2024). In 2020, the estimated population was around 230,871, with an annual growth rate of 1.91% (World Bank 2023). Fisheries play a fundamental role in the country's economy and food security, supplying approximately 85% of the population's animal protein intake (Zacarias et al. 2022). Artisanal fishing is the dominant fishing activity, employing approximately 4155 fishers and 3296 women involved in processing and trading fish products (Directorate of Fisheries—Democratic Republic of São Tomé and Príncipe [DF-DRSTP] 2019; Zacarias et al. 2022). The artisanal fleet, composed of around 2336 small boats, primarily operates in nearshore waters, landing approximately 8654 tonnes of fish in 2017, with most of the catch sold fresh in local markets (Zacarias et al. 2022).

The main fishery resources in São Tomé and Príncipe include large pelagic species (58% of total catch), small coastal pelagics (21%), demersal fish (7%), and crustaceans and cephalopods (14%; DF-DRSTP 2015; Food and Agriculture Organization [FAO] 2021; Zacarias et al. 2022). Despite their economic and ecological importance, biological data on these species remain insufficient for conventional stock assessment methods. The absence of systematic surveys and regular data collection poses challenges to effective fisheries management and increases the risk of overexploitation.

Among the key data deficiencies, the lack of species-specific LWR, sex ratio, and condition factor information represents a significant gap, reducing the accuracy of stock assessments and biomass estimations (Porriños 2021; Zacarias et al. 2021). To address this issue, this study provides the first reference values for these life-history traits of 10 fish species commonly caught in the coastal waters of southern São Tomé Island: *Dentex macrophthalmus* (Bloch, 1791), *Dentex congoensis* Poll, 1954, *Pagrus caeruleostictus* (Valenciennes, 1830), *Lethrinus atlanticus* Valenciennes, 1830, *Lutjanus fulgens* (Valenciennes, 1830), *Lutjanus goreensis* (Valenciennes, 1830), *Lutjanus agennes* Bleeker, 1863, *Apsilus fuscus* Valenciennes, 1830, *Pomadasys rogerii* (Cuvier, 1830), and *Paranthias furcifer* (Valenciennes, 1828). These findings will serve as a baseline for future fisheries research, enhance stock monitoring, and support the development of science-based management strategies for the region's fishery resources.

2 | Materials and Methods

2.1 | Data Collection

This study analysed fish randomly collected by local artisanal fishers during fishing trips from March 2019 to February 2020 at eight sites between Angolares and Porto Alegre, in southern São Tomé Island (Figure 1). Fishing occurred an average of three times per week, both in the morning and afternoon, using a combination of handline techniques. This included vertical longlines (0.70–0.90 mm) equipped with 5–12 branch lines (0.60–0.70 mm) fitted with No. 9–12 hooks; horizontal longlines (0.80–0.90 mm) with 100–500 branch lines, also with No. 9–12 hooks; and single-hook artificial lures, locally known as 'tchapo', composed of a No. 9 or 10 hook with lead or tin attached to wire (0.30–0.70 mm). Fishing activities took place at depths ranging from 7 to 100 m. Each fishing session lasted between 30 and 60 min, depending on peak fish abundance. Although sampling occurred continuously throughout all months of the year, the single-year duration restricted the possibility of conducting robust seasonal analyses.

2.2 | Data Analysis

Specimens from the following species were analysed: *D. macrophthalmus*, *D. congoensis*, *P. caeruleostictus*, *L. atlanticus*, *L. fulgens*, *L. goreensis*, *L. agennes*, *A. fuscus*, *P. rogerii*, and *P. furcifer*. Total length (TL) of each fish specimen was measured using a metric ruler with an accuracy of 0.1 cm, while total weight (TW) was recorded with a digital bench scale (Electronic Ohaus) precise to 0.01 g. Gonadal macroscopic analysis was performed to determine the sex of each specimen. A low number of immature fish and a restricted sampling period limited the assessment of seasonal variation in energy allocation and the accurate estimation of size at maturity.

The homogeneity of variances in TL between sexes was evaluated separately for each species using Levene's test (Levene 1960). Because this test indicated unequal variances between male and female groups in several species (Table S1), we used Welch's heteroscedastic *F*-test to assess differences in mean TL between sexes. We applied a Bonferroni post hoc correction to account for multiple comparisons.

The male-to-female ratio (M:F) was analysed across TL classes, and a chi-square test was used to evaluate whether sex ratios significantly deviated from the expected 1:1 proportion.

The LWR was calculated separately for males, females, and pooled sexes using the equation $TW = aTL^b$. Following residual analysis to ensure the validity of the model, log-transformed TL and TW values were used to estimate the parameters a (intercept) and b (growth coefficient) through simple linear regression using the least-squares method, implemented in the FSA R package (Ogle et al. 2025).

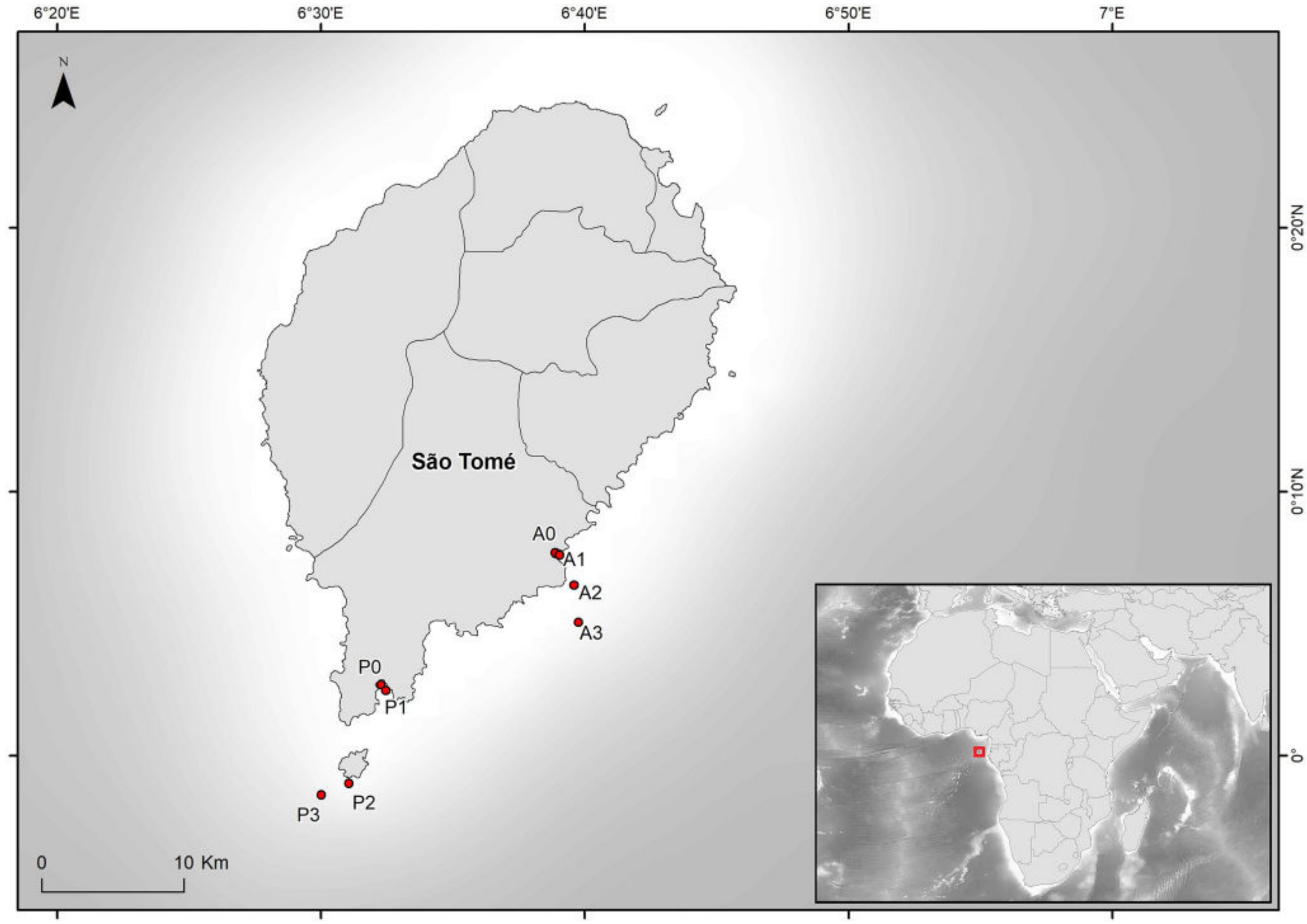

FIGURE 1 | Map showing the distribution of eight sampling sites surveyed during the scientific fishing campaign (March 2019–February 2020) in the southern part of São Tomé Island. Sites were located between the Angolares (A) and Porto Alegre (P) regions, where the data were randomly collected by local artisanal fishers.

Growth patterns were classified based on the estimated b value: isometric growth ($b = 3$) indicates a proportional increase in weight relative to length, whereas allometric growth occurs when b differs from 3 (positive allometry if $b > 3$, negative allometry if $b < 3$). A t-test was performed for each LWR to determine whether the estimated b value significantly differed from the isometric growth assumption ($b = 3$) at $p < 0.05$.

An analysis of covariance (ANCOVA) was conducted to assess whether the LWR parameters differed significantly between males and females, specifically testing for differences in both b and a. If the interaction between sex and log-transformed length was significant, this indicated that the growth rates (b) differed between sexes. If only the main effect of sex was significant, this suggested a difference in the intercept (a) between males and females.

The condition factor (K), an indicator of fish health and robustness, was calculated using following Fulton's equation (Fulton 1904):

$K = 100 \times W/L^3$, where W is the total weight (g) and L is the total length (cm). A K value greater than 1 generally indicates a well-conditioned fish population (Morton and Routledge 2006; Kumar et al. 2023).

3 | Results

3.1 | Size Structure

A total of 1417 individuals (637 males, 781 females) from 10 fish species were collected from the coastal waters of the southern region of São Tomé Island. Variation in size and weight was observed among species (Table 1). The length-frequency distributions for each species are summarized in Figure 2. Species-specific differences in size distribution were evident, with some species showing significant sexual size dimorphism (Table 2). *Dentex macrophthalmus* ranged from 12.5 to 32.5 cm and 30 to 494 g, with females (24.26 ± 4.83 cm) larger than males (18.27 ± 4.01 cm; Welch's test, $p < 0.001$). *Dentex congoensis* measured 12.5–32 cm and weighed 28–295 g, with females (17.74 ± 2.97 cm) larger than males (15.97 ± 2.04 cm; Welch's test, $p < 0.001$). *Pagrus caeruleostictus* ranged from 14.5 to 32.5 cm and 48 to 497 g, with females (26.47 ± 4.34 cm) larger than males (19.51 ± 3.47 cm; Welch's test, $p < 0.001$). *Lethrinus atlanticus* ranged from 7.5 to 37 cm and 6 to 804 g, with males (24.63 ± 3.44 cm) larger than females (21.47 ± 6.19 cm; Welch's test, $p < 0.001$). *Lutjanus goreensis* measured 11–40 cm and weighed 20–300 g, with males (23.23 ± 5.94 cm) larger than females (18.22 ± 3.36 cm; Welch's test, $p < 0.001$). *Lutjanus agennes* ranged from 12 to 40 cm and 60 to 970 g, with males (24.16 ± 4.27 cm) larger than females (20.05 ±

TABLE 1 | Summary statistics and regression parameters of length–weight relationships (LWR) and condition factor (*K*) for the 10 commercially important fish species caught in the coastal waters of southern São Tomé Island.

Species	Sex	N	TL (cm)	TW (g)	*a*	*b*	R^2	*t*	*p* value	Growth type	*K*
Dentex macrophthalmus	Female	65	14.5–32.5	45–494	0.042 (0.021–0.087)	2.664 (2.437–2.892)	0.897	−2.951	0.004	A−	1.492
	Male	90	12.5–30	30–396	0.013 (0.009–0.021)	3.035 (2.887–3.183)	0.950	0.470	0.640	I	1.508
	Pooled	155	12.5–32.5	30–494	0.020 (0.015–0.028)	2.895 (2.788–3.003)	0.949	−1.927	0.056	I	1.503
Dentex congoensis	Female	119	13.5–32	40–295	0.020 (0.013–0.032)	2.889 (2.735–3.042)	0.922	−1.435	0.154	I	1.493
	Male	33	12.5–22	28–160	0.028 (0.018–0.043)	2.777 (2.620–2.934)	0.977	−2.892	0.007	A−	1.503
	Pooled	152	12.5–32	28–295	0.022 (0.015–0.031)	2.868 (2.746–2.989)	0.935	−2.153	0.033	A−	1.494
Pagrus caeruleostictus	Female	67	17.5–32.5	75–494	0.105 (0.050–0.221)	2.378 (2.152–2.605)	0.871	−5.480	<0.001	A−	1.413
	Male	71	15.4–31	55–355	0.049 (0.021–0.114)	2.581 (2.295–2.867)	0.824	−2.923	0.005	A−	1.438
	Pooled	136	14.5–32.5	48–396	0.038 (0.025–0.058)	2.677 (2.537–2.816)	0.915	−4.588	<0.001	A−	1.42
Lethrinus atlanticus	Female	90	7.5–37	6–804	0.021 (0.016–0.028)	2.882 (2.789–2.975)	0.977	−2.513	0.014	A−	1.525
	Male	85	17.5–32.5	80–467	0.026 (0.018–0.038)	2.826 (2.712–2.940)	0.967	−3.028	0.003	A−	1.5
	Pooled	175	7.5–37	6–804	0.021 (0.017–0.026)	2.889 (2.826–2.953)	0.979	−3.448	0.001	A−	1.514
Lutjanus goreensis	Female	101	14.2–40	20–300	0.114 (0.047–0.279)	2.231 (1.922–2.539)	0.675	−4.949	<0.001	A−	1.272
	Male	35	15.1–35	45–280	0.131 (0.051–0.335)	2.207 (1.906–2.508)	0.871	−5.358	<0.001	A−	1.147
	Pooled	136	11–40	20–323	0.169 (0.113–0.254)	2.122 (1.986–2.258)	0.876	−12.757	<0.001	A−	1.31
Lutjanus fulgens	Female	67	16.5-39.5	60–970	0.009 (0.006–0.012)	3.132 (3.025–3.240)	0.981	2.453	0.017	A+	1.341
	Male	37	19.5–32	106-471	0.025 (0.010–0.062)	2.814 (2.520–3.109)	0.915	−1.282	0.208	I	1.382
	Pooled	105	13.4-39.5	44–970	0.028 (0.017–0.047)	2.743 (2.581–2.905)	0.916	−3.145	0.002	A−	1.289
Lutjanus agennes	Female	78	14.3–39.5	60–970	0.006 (0.003–0.011)	3.287 (3.098–3.477)	0.940	3.015	0.003	A+	1.451
	Male	67	19.5–40	107–970	0.070 (0.023–0.212)	2.474 (2.124–2.824)	0.754	−3.003	0.004	A−	1.349
	Pooled	145	12–40	60–970	0.028 (0.016–0.049)	2.771 (2.590–2.952)	0.865	−2.502	0.013	A−	1.449
Apsillus fucus	Female	75	17.5–42	35–390	0.092 (0.030–0.286)	2.161 (1.826–2.497)	0.693	−4.981	<0.001	A−	0.567
	Male	56	25.9–56.7	110–785	0.091 (0.022–0.379)	2.200 (1.821–2.579)	0.715	−4.233	<0.001	A−	0.468
	Pooled	131	20.5–56.7	75–785	0.095 (0.061–0.148)	2.187 (2.061–2.313)	0.902	−12.794	<0.001	A−	0.548
Pomadasys rogerii	Female	57	23.7–38	170–567	0.196 (0.060–0.644)	2.212 (1.875–2.549)	0.759	−4.685	<0.001	A−	1.24
	Male	75	9.5–25.5	11–115	0.102 (0.044–0.233)	2.160 (1.826–2.494)	0.695	−5.010	<0.001	A−	1.333
	Pooled	132	9.5–38	11–567	0.014 (0.010–0.017)	2.960 (2.873–3.047)	0.972	−0.913	0.363	I	1.246
Paranthias furcifer	Female	62	25–31	145–321	0.002 (0.000–0.012)	3.515 (2.974–4.056)	0.738	1.903	0.062	I	1.092
	Male	88	18.5–27.5	70–245	0.017 (0.008–0.033)	2.872 (2.654–3.090)	0.889	−1.170	0.245	I	1.123
	Pooled	150	18.5–31	70–321	0.015 (0.009–0.023)	2.907 (2.766–3.047)	0.919	−1.316	0.190	I	1.11

Note: a: intercept (body form parameter) and *b*: slope (growth coefficient) with 95% confidence intervals in brackets; R^2: coefficient of determination; *t*: Student's *t*-test statistic and *p*-value for *b* isometric assumption; growth type: allometry positive (A+); allometry negative (A−); isometric growth (I); *K*: condition factor.
Abbreviations: TL, total length; TW, total weight.

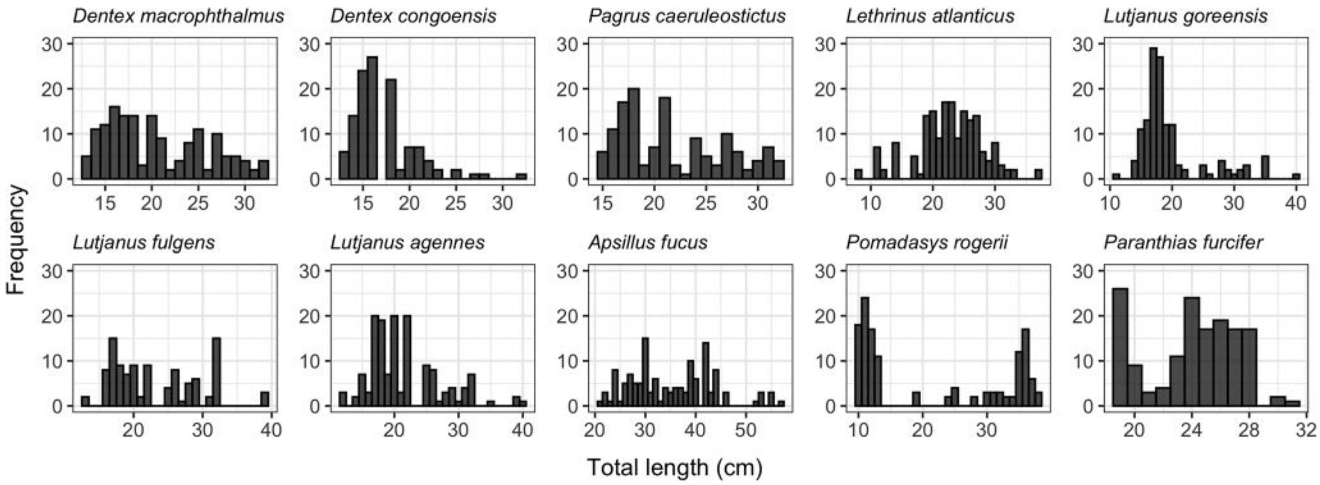

FIGURE 2 | Length–frequency distribution of the 10 fish species from the São Tomé Island sampled during the 2019–2020 period.

TABLE 2 | Results of Welch's heteroscedastic *F*-test assessing differences in mean total length (TL) between sexes for each species.

Species	Male TL (cm)	Female TL (cm)	*F*	*p* value
Dentex macrophthalmus	18.27 (4.01)	24.26 (4.83)	−8.18	<0.001
Dentex congoensis	15.97 (2.04)	17.74 (2.97)	−3.96	<0.001
Pagrus caeruleostictus	19.51 (3.47)	26.47 (4.34)	−10.38	<0.001
Lethrinus atlanticus	24.63 (3.44)	21.47 (6.19)	4.21	<0.001
Lutjanus goreensis	23.23 (5.94)	18.22 (3.36)	4.74	<0.001
Lutjanus fulgens	23.77 (3.99)	22.55 (6.82)	1.16	0.250
Lutjanus agennes	24.16 (4.27)	20.05 (5.56)	5.03	<0.001
Apsillus fucus	42.77 (5.9)	29.42 (5.11)	13.56	<0.001
Pomadasys rogerii	12.11 (2.9)	34.14 (3.62)	−37.65	<0.001
Paranthias furcifer	22.28 (2.76)	26.89 (1.4)	−13.45	<0.001

Note: Mean TL values are presented with standard deviation in brackets.

5.56 cm; Welch's test, $p < 0.001$). *Lutjanus fulgens* ranged from 13.4 to 39.5 cm and 44 to 970 g, with no significant difference between males (23.77 ± 3.99 cm) and females (22.55 ± 6.82 cm; Welch's test, $p = 0.250$). *Pomadasys rogerii* ranged from 9.5 to 38 cm and 11 to 567 g, with females (34.14 ± 3.62 cm) larger than males (12.11 ± 2.90 cm; Welch's test, $p < 0.001$). *Apsilus fucus* ranged from 17.5 to 56.7 cm and 35 to 785 g, with males (42.77 ± 5.90 cm) larger than females (29.42 ± 5.11 cm; Welch's test, $p < 0.001$). *Paranthias furcifer* measured 18.5 to 31 cm and weighed 70 to 321 g, with females (26.89 ± 1.40 cm) larger than males (22.28 ± 2.76 cm; Welch's test, $p < 0.001$).

3.2 | Sex Ratio

The overall sex ratio (M:F) varied among species, with significant deviations observed in *D. macrophthalmus* (1.38:1; chi-square test, $p = 0.045$) and *P. furcifer* (1.42:1; chi-square test, $p = 0.034$), where males were more abundant than females, while *Dentex congoensis* (0.28:1; chi-square test, $p < 0.001$), *L. goreensis* (0.35:1; chi-square test, $p < 0.001$), and *L. fulgens* (0.55:1; chi-square test, $p = 0.003$) showed a predominance of females (Table 3). Length-dependent sex ratio patterns varied across species (Figure 3). In several species, females were more abundant at larger sizes, particularly in *D. congoensis*, *D. macrophthalmus*, *P. caeruleostictus*, *L. fulgens*, *P. rogerii*, and *P. furcifer*. In these same species, males were more frequent at smaller sizes. A different pattern was observed in *L. atlanticus*, *L. goreensis*, *L. fulgens*, *L. agennes*, and *A. fucus*, where females were more common in smaller size classes. *Apsilus fucus* was the only species where males predominated at larger sizes. Some species showed a higher proportion of males in intermediate size ranges (20–30 cm), particularly *L. goreensis*, *L. fulgens*, and *L. agennes*.

3.3 | Length–Weight Relationship

The LWRs showed high determination coefficients ($R^2 = 0.675$–0.981), indicating a strong model fit across most species (Table 1). The lowest R^2 values were observed for females of *L. goreensis* ($R^2 = 0.675$), *A. fucus* ($R^2 = 0.693$), *P. furcifer* ($R^2 = 0.738$), and males of *P. rogerii* ($R^2 = 0.695$), suggesting higher variability in weight prediction for these groups. The intercept (a) values ranged from 0.002 in female *P. furcifer* to 0.196 in female *P. rogerii*, reflecting species-specific differences in body form. The slope (b) values varied between 2.122 in pooled *L. goreensis* (negative

TABLE 3 | Results of the chi-squared test evaluating whether the sex ratio significantly deviates from the expected 1:1 ratio for each species.

Species	Male:female ratio	Chi-square	*p* value
Dentex macrophthalmus	1.38:1	4.03	0.045
Dentex congoensis	0.28:1	48.66	<0.001
Pagrus caeruleostictus	1.06:1	0.12	0.734
Lethrinus atlanticus	0.94:1	0.14	0.706
Lutjanus goreensis	0.35:1	32.03	<0.001
Lutjanus fulgens	0.55:1	8.65	0.003
Lutjanus agennes	0.86:1	0.83	0.361
Apsillus fucus	0.75:1	2.76	0.097
Pomadasys rogerii	1.32:1	2.46	0.117
Paranthias furcifer	1.42:1	4.51	0.034

Note: The male:female ratio is calculated as the number of males divided by the number of females, with a reference value of 1 for females.

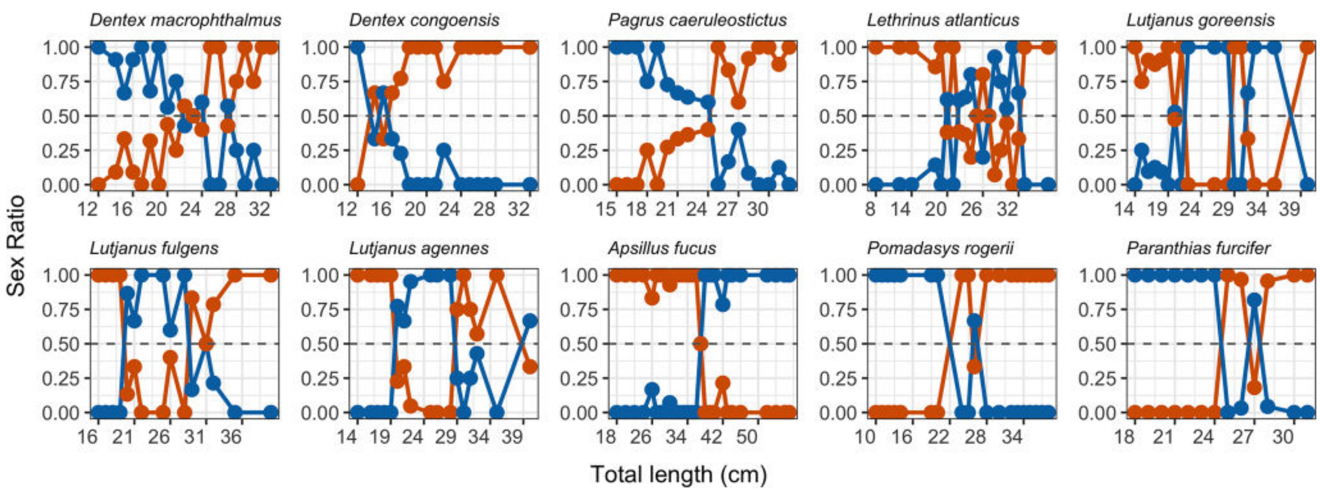

FIGURE 3 | Proportion of males (in blue) and females (in orange) of the 10 fish species by size class in the southern part of São Tomé Island during the period 2019–2020.

allometry) and 3.515 in female *P. furcifer* (positive allometry; Table 1). Negative allometry ($b < 3$) was the most common pattern, observed in 70% of the cases (14 out of 20). Positive allometry ($b > 3$) occurred in 20% of the cases (4 out of 20), while isometric growth ($b = 3$) accounted for the remaining 10% (2 out of 20).

Sex-related differences in LWRs were observed in several species, with significant variation in either a or b between males and females (Tables 1 and 4; Figures 4 and 5). In *D. macrophthalmus*, while no significant difference was detected in a (ANCOVA, $p = 0.603$), females exhibited negative allometry ($b = 2.664$; t-test, $p = 0.004$), whereas males showed isometric growth ($b = 3.035$; t-test, $p = 0.640$; ANCOVA, $p = 0.005$). *Pagrus caeruleostictus* exhibited a significant difference in a, with males having a higher value ($a = 0.049$) than females ($a = 0.105$; ANCOVA, $p = 0.001$), but both sexes displayed negative allometry (females: $b = 2.378$; t-test, $p < 0.001$; males: $b = 2.581$; t-test, $p = 0.005$; ANCOVA, $p = 0.270$). In *L. fulgens*, the intercept (a) did not differ significantly (ANCOVA, $p = 0.381$), but females exhibited positive allometry ($b = 3.132$; t-test, $p = 0.017$), whereas males had isometric growth ($b = 2.814$; t-test, $p = 0.208$; ANCOVA, $p = 0.031$). In *L. agennes*, males had a significantly higher intercept ($a = 0.070$) than females ($a = 0.006$; ANCOVA, $p = 0.032$). Additionally, females exhibited positive allometry ($b = 3.287$; t-test, $p = 0.003$), while males showed negative allometry ($b = 2.474$; t-test, $p = 0.004$; ANCOVA, $p < 0.001$). In *P. furcifer*, the intercept did not differ between sexes (ANCOVA, $p = 0.614$). However, females exhibited a significantly higher b value ($b = 3.515$) than males ($b = 2.872$; ANCOVA, $p = 0.043$). Despite this difference, the assumption of isometry could not be rejected at the 0.05 significance level for either sex (females: t-test, $p = 0.062$; males: t-test, $p = 0.245$).

In contrast, several species showed no significant sex-based differences in LWRs. In *D. congoensis*, females exhibited isometry ($b = 2.889$; t-test, $p = 0.154$), while males showed negative allometry ($b = 2.777$; t-test, $p = 0.007$). However, ANCOVA did not detect significant differences in either the intercept ($p = 0.988$) or b values between sexes ($p = 0.537$). In *L. atlanticus*, males and females both exhibited negative allometry (females: $b = 2.882$; t-test, $p = 0.014$; males: $b = 2.826$; t-test, $p = 0.003$; ANCOVA, $p = 0.562$). Similarly, in *L. goreensis*, both sexes showed negative allometry, with females ($b = 2.231$; t-test, $p < 0.001$) having slightly higher values than males ($b = 2.207$; t-test, $p < 0.001$; ANCOVA, $p = 0.913$). *Apsilus fucus* followed the same trend, with females ($b =$

TABLE 4 | Results of the ANCOVA assessing differences in length–weight relationships between sexes for each species.

Species	Source	*df*	SS	MS	*F*	*p* value	Description
Dentex macrophthalmus							
	logTL		81.31	81.31	2951.31	<0.001	TL significantly influences TW
	Sex		0.01	0.01	0.27	0.603	No significant difference in *a* values between sexes
	logTL:Sex		0.22	0.22	8.10	0.005	M and F have significantly different *b* values
	Residuals	151	4.16	0.03			
Dentex congoensis							
	logTL		28.21	28.21	2121.43	<0.001	TL significantly influences TW
	Sex		0.00	0.00	0.00	0.988	No significant difference in *a* values between sexes
	logTL:Sex		0.01	0.01	0.38	0.537	No significant difference in *b* values between sexes
	Residuals	148	1.97	0.01			
Pagrus caeruleostictus							
	logTL		51.70	51.70	1556.66	<0.001	TL significantly influences TW
	Sex		0.38	0.38	11.45	0.001	M and F have significantly different *a* values
	logTL:Sex		0.04	0.04	1.23	0.270	
	Residuals	134	4.45	0.03			
Lethrinus atlanticus							
	logTL		100.27	100.27	7798.89	<0.001	TL significantly influences TW
	Sex		0.01	0.01	0.98	0.323	No significant difference in *a* values between sexes
	logTL:Sex		0.00	0.00	0.34	0.562	No significant difference in *b* values between sexes
	Residuals	171	2.20	0.01			
Lutjanus goreensis							
	logTL		28.84	28.84	577.03	<0.001	TL significantly influences TW
	Sex		0.08	0.08	1.56	0.213	No significant difference in *a* values between sexes
	logTL:Sex		0.00	0.00	0.01	0.913	No significant difference in *b* values between sexes
	Residuals	132	6.60	0.05			
Lutjanus fulgens							
	logTL		59.83	59.83	3607.84	<0.001	TL significantly influences TW
	Sex		0.01	0.01	0.77	0.381	No significant difference in *a* values between sexes
	logTL:Sex		0.08	0.08	4.80	0.031	M and F have significantly different b values
	Residuals	100	1.66	0.02			
Lutjanus agennes							
	logTL		65.32	65.32	1464.95	<0.001	TL significantly influences TW
	Sex		0.21	0.21	4.70	0.032	M and F have significantly different *a* values
	logTL:Sex		0.80	0.80	17.91	<0.001	M and F have significantly different *b* values
	Residuals	141	6.29	0.04			

(Continues)

TABLE 4 | (Continued)

Species	Source	df	SS	MS	F	p value	Description
Apsillus fucus							
	logTL		45.20	45.20	837.33	<0.001	TL significantly influences TW
	Sex		0.24	0.24	4.40	0.038	M and F have significantly different *a* values
	logTL:Sex		0.00	0.00	0.02	0.888	No significant difference in *b* values between sexes
	Residuals	127	6.86	0.05			
Pomadasys rogerii							
	logTL		327.02	327.02	6455.14	<0.001	TL significantly influences TW
	Sex		1.90	1.90	37.57	<0.001	M and F have significantly different *a* values
	logTL:Sex		0.00	0.00	0.03	0.860	No significant difference in *b* values between sexes
	Residuals	128	6.48	0.05			
Paranthias furcifer							
	logTL		24.23	24.23	1702.94	<0.001	TL significantly influences TW
	Sex		0.00	0.00	0.25	0.614	No significant difference in *a* values between sexes
	logTL:Sex		0.06	0.06	4.15	0.043	M and F have significantly different *b* values
	Residuals	146	2.08	0.01			

Abbreviations: *df*, degrees of freedom; MS, mean sum of squares; SS, sum of squares.

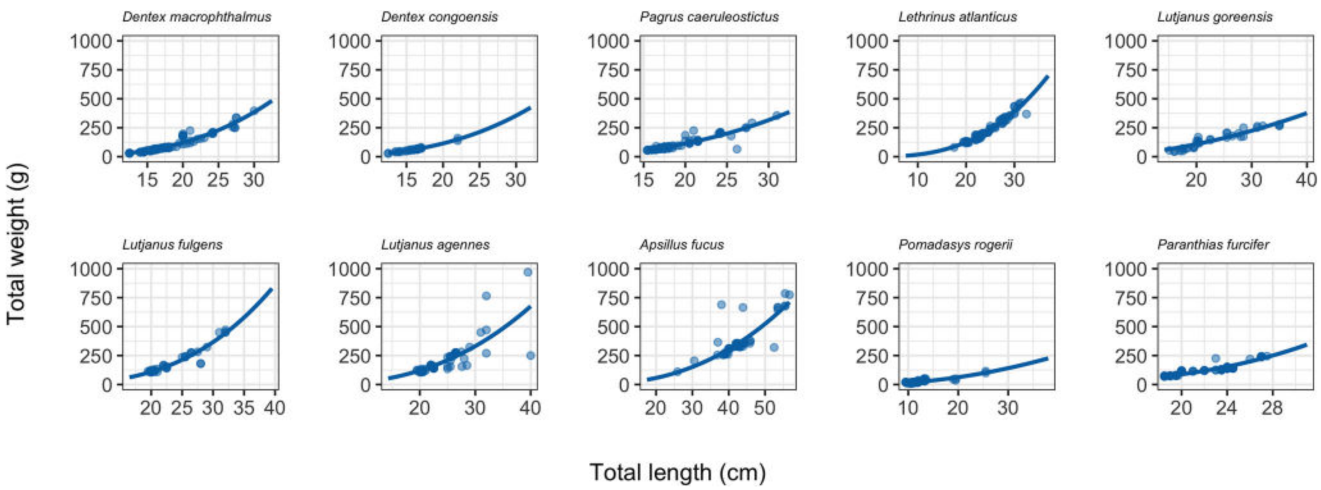

FIGURE 4 | Length–weight relationship of males of the 10 fish species from the São Tomé Island sampled during the period 2019–2020.

2.161; *t*-test, $p < 0.001$) and males ($b = 2.200$; *t*-test, $p < 0.001$) both displaying negative allometry (ANCOVA, $p = 0.888$). In *P. rogerii*, both sexes exhibited negative allometry (females: $b = 2.212$; *t*-test, $p < 0.001$; males: $b = 2.160$; *t*-test, $p < 0.001$) with no significant differences between sexes (ANCOVA, $p = 0.860$).

3.4 | Condition Factor

Fulton's condition factor (K) ranged from 0.460 to 1.550 across species and sexes (Table 1). The highest values were observed in female *L. atlanticus* ($K = 1.525$), followed by male *D. macrophthalmus* ($K = 1.508$) and male *D. congoensis* ($K = 1.503$). The lowest K values were recorded in *A. fuscus*, with females at 0.567 and males at 0.468. In species where females had higher K values than males, the largest differences were observed in *L. goreensis* ($K = 1.272$ vs. 1.147), *L. agennes* ($K = 1.451$ vs. 1.349), and *A. fuscus* ($K = 0.567$ vs. 0.468). Smaller differences in favour of females were found in *L. atlanticus* ($K = 1.525$ vs. 1.500). In species where males had higher K values than females, the largest differences were observed in *P. rogerii* ($K = 1.333$ vs. 1.240). Slight differences in favour of males were found in *P. caeruleostictus* ($K = 1.438$ vs. 1.413), *P. furcifer* ($K = 1.123$ vs. 1.092), *L. fulgens* ($K = 1.382$ vs. 1.341), *D. macrophthalmus* ($K = 1.508$ vs. 1.492), and *D. congoensis* ($K = 1.503$ vs. 1.493).

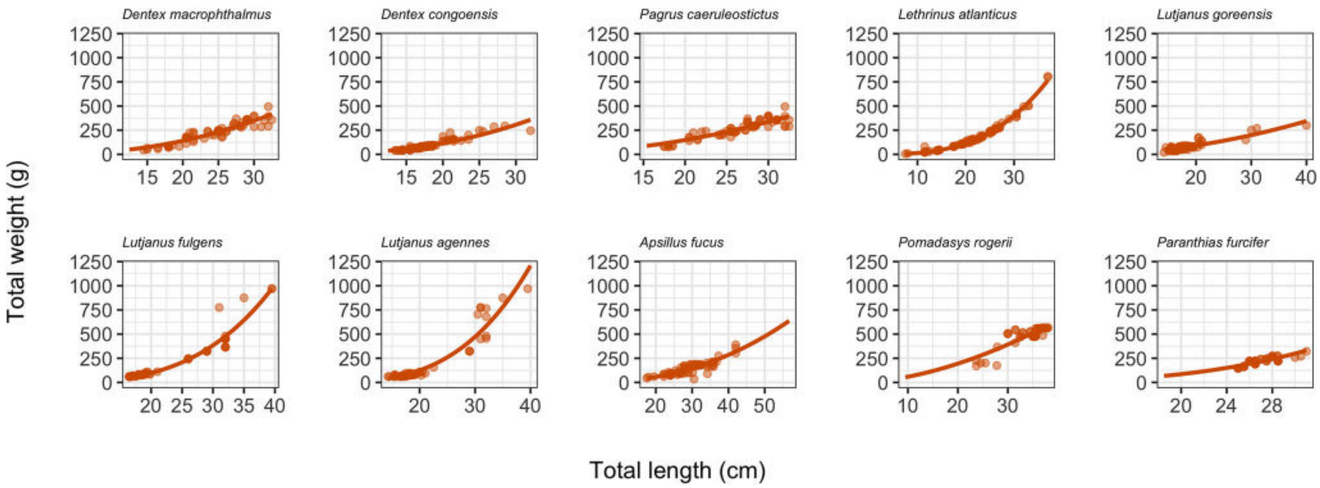

FIGURE 5 | Length–weight relationship of females of the 10 fish species from the São Tomé Island sampled during the period 2019–2020.

4 | Discussion

The present study provides the first comprehensive evaluation of biometric parameters—LWRs, sex ratios, and Fulton's condition factor (K)—for 10 demersal teleost species sampled in the southern coastal waters of São Tomé Island. These data offer essential baselines for fisheries assessment in a region where biological information remains scarce, particularly for small-scale artisanal fisheries.

A new maximum total length was recorded for *P. furcifer* (31.0 cm), exceeding the values currently available in FishBase (Froese and Pauly 2025). In *A. fuscus*, the maximum total length (56.7 cm) was similar to those reported in Cape Verde (Oliveira et al. 2015; Santos et al. 2013) and Ghana (Aggrey-Fynn and Hotor 2021), suggesting consistency in growth potential across its distribution range. Comparable results were also observed for *L. goreensis* and *L, agennes* (40.0 cm), which fall between the estimates from Razi and Noori (2018), Aggrey-Fynn and Hotor (2021), and Fakoya et al. (2020) and those described in the FAO Species Catalogue by Allen (1985), where values of up to 60.0 cm are reported. *Dentex macrophthalmus* reached 32.5 cm in this study, below the 36.0 cm previously reported in São Tomé by Zacarias et al. (2021). Differences in maximum size between studies may be related to fishing pressure, gear selectivity, or temporal variability in population structure (Kendall and Quinn 2012; Tu et al. 2018).

The LWR analyses demonstrated that most species exhibited negative allometric growth ($b < 3$), suggesting that individuals tend to increase in length faster than in weight. This is a common trend in tropical demersal fish and may reflect energetic constraints associated with limited food availability, reproductive investment, or environmental stress (Jobling, 2002; Mahé et al. 2023). In contrast, positive allometry in females of *L. fulgens* and *P. furcifer* suggests enhanced energy allocation to somatic or gonadal tissues during certain life stages, possibly linked to pre-spawning development (Hsieb et al. 2024). These results align with earlier observations in other lutjanid species (Hsieb et al. 2024; Mahé et al. 2023; de Morais et al. 2015; Olopade and Dienye 2018; Santos et al. 2013; Soykan et al. 2015; Van et al. 2019) and reinforce the importance of disaggregated biometric analyses in sexually dimorphic populations.

The range of b values observed (2.122–3.515) is consistent with findings in other tropical marine environments and reflects the influence of both intrinsic (sex, age, reproductive condition) and extrinsic (temperature, salinity, trophic availability) factors on growth (Falsone et al. 2022; Lal et al. 2023). Although statistical tests (ANCOVA) did not detect significant differences between sexes in all species, biologically meaningful variation in b values was evident in species such as *L. agennes* and *D. macrophthalmus*, where females tended towards positive or isometric growth, while males exhibited negative allometry. Similar patterns have been reported in other studies (Chen et al. 2022; Mahé et al. 2023), highlighting the need for sex-specific assessments in biometric modelling.

Negative allometric growth was also detected in both sexes of *L. atlanticus*, confirming the patterns observed by Lidour et al. (2018) and Konney et al. (2023). Females of *L. agennes* ($b = 3.287$) and *P. furcifer* ($b = 3.514$) demonstrated positive allometry, in agreement with values reported by Santos et al. (2013), Soykan et al. (2015), Olopade and Dienye (2018), and Mahé et al. (2023). *Dentex congoensis* presented near-isometric growth in females and negative allometry in males, consistent with findings in Nigerian and Kenyan waters (Aura et al. 2013; Omogoriola et al. 2011). For *D. macrophthalmus*, females showed negative allometry ($b = 2.664$), corroborating the estimates from Santos et al. (2013), Zacarias et al. (2021), and Ragheb (2023), while males approached isometry.

In *A. fuscus*, negative allometric growth in both sexes contradict the isometric patterns observed in Ghana and the Indian coast (Aggrey-Fynn and Hotor 2021; Rajitha and Pillai 2015), as well as the positive allometry recorded in Nigeria and Cape Verde (Oliveira et al. 2015; Santos et al. 2013). Similarly, the b values recorded for *P. rogerii* (female: 2.212; male: 2.160) contrast with studies reporting isometric or positive allometry (Adebiyi 2013; Avsar et al. 2021; Rodríguez-García et al. 2023; Sangun et al. 2007). These discrepancies are likely due to local environmental gradients, feeding intensity, or reproductive condition during sampling (Falsone et al. 2022; Lal et al. 2023).

Sex ratio analysis showed statistically significant deviations from parity in several species. Male-biased populations were observed in *D. macrophthalmus* and *P. furcifer*, while *D. congoensis*, *L. goreensis*, and *L. fulgens* showed female predominance. Similar patterns have been reported in other tropical species (Masri 2023; Mohdeb and Kara 2014). These skewed sex ratios may reflect differential habitat use, variation in growth or mortality rates between sexes, or gear selectivity. The greater abundance of females in larger size classes, as observed in multiple species, may be indicative of longer female longevity or slower growth and earlier mortality in males (Hsieb et al. 2024; Zhu et al. 2025). Although there is no evidence of sex change mechanisms in the species studied, these sex-specific patterns should be considered in the context of reproductive output and resilience to fishing pressure.

Fulton's condition factor (K) varied across species and sexes, reflecting differences in energy reserves and overall physiological status. Most species showed K values consistent with good health and sufficient energy intake. However, *A. fuscus* presented notably low values in both sexes, suggesting possible nutritional stress, suboptimal environmental conditions, or high reproductive investment during sampling (Oliveira et al. 2015; Razi and Noori 2018). Similar values were previously reported by Zacarias et al. (2021) and Aggrey-Fynn and Hotor (2021). In contrast, *L. atlanticus* exhibited high K values in both sexes, suggesting favourable trophic conditions or reduced competition. These results are in line with those of Jebarani et al. (2021), Zacarias et al. (2021), and Ragheb (2023) and underscore the importance of considering species-specific ecological niches when interpreting condition factor values.

Given the sensitivity of K to seasonal cycles and reproductive status, future studies should incorporate additional indicators such as the gonadosomatic index and histological analyses to validate physiological interpretations (Singh et al. 2022; Vinothkumar et al. 2022). Integrating biometric indicators with environmental and trophic data will also enhance the resolution of population health assessments and support more effective management interventions.

5 | Conclusions

This study provides the first LWRs, sex ratios, and condition factor estimates for 10 commercially important demersal species in São Tomé and Príncipe. These biometric parameters offer essential baseline data to support biomass estimation, population health assessments, and fisheries management in a region facing increasing anthropogenic and environmental pressures. The results highlight interspecific variation in growth and condition, reinforcing the importance of sex-disaggregated analyses and regular local monitoring. These findings contribute to ongoing stock assessments and the development of science-based conservation strategies for small-scale fisheries in the Gulf of Guinea. Future studies should aim to extend the sampling period—ideally through collaboration with relevant authorities to obtain longer term sampling permits—in order to allow seasonal and finer scale temporal assessments of growth, condition, and reproductive dynamics.

Author Contributions

Wilfred Boa Morte Zacarias conceived the original idea, conducted the data analysis and interpretation, and drafted the manuscript. Qinhua Fang and Gnoumasse Sidibe provided comments that helped shape the draft version. Régis Santos contributed to the data analysis and interpretation and participated in writing the final version of the manuscript.

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Ethics Statement

This study did not involve any experimental procedures on live animals. All fish analysed were obtained from artisanal fishers during their routine fishing operations, and no specimens were captured, handled, or sacrificed specifically for research purposes. In accordance with institutional and national regulations, studies using dead fish sourced from commercial catches do not require formal ethical approval. All handling and biometric measurements followed the relevant guidelines for good scientific practice.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

References

Abebiyi, F. A. 2013. "Length-Frequency Distribution, Length-Weight Relationship and Condition Factor of Sompat Grunt *Pomadasys jubelini* (Cuvier, 1830) off Lagos Coast, Nigeria." *Pertanika Journal of Tropical Agricultural Science* 36, no. 4: 337–344.

Aggrey-Fynn, J., and D. W. Hotor. 2021. "Growth, Mortality and Exploitation Levels of *Sphyraena sphyraena* (Pisces: Sphyraenidae) and *Apsilus fuscus* (Pisces: Lutjanidae) in Ghanaian Waters." *European Journal of Environment and Earth Sciences* 2, no. 1: 16–23. https://doi.org/10.24018/ejgeo.2021.2.1.108.

Allen, G. R. 1985. *FAO Species Catalogue. Vol. 6. Snappers of the World. An Annotated and Illustrated Catalogue of Lutjanid Species Known to Date* (FAO Fisheries Synopsis No. 125, Vol. 6, p. 208). Food and Agriculture Organization.

Aura, C. M., R. O. Anam, S. Musa, and E. Kimani. 2013. "Length-Weight Relationship and Condition Factor (K Constant) of *Dentex maroccanus*, Valenciennes 1830 (Family Sparidae) at Malindi, Kenya." *Western Indian Ocean Journal of Marine Science* 12, no. 1: 79–83.

Avsar, D., S. Mavruk, H. Yeldan, and M. Manasirli. 2021. "Population Dynamics of an Emergent Invasive Fish, Striped Piggy, *Pomadasys Stridens* (Actinopterygii, Perciformes, Haemulidae) in the Gulf of İskenderun, North-Eastern Mediterranean." *Acta Ichthyologica et Piscatoria* 51, no. 1: 13–21. https://doi.org/10.3897/aiep.51.63320.

Coll, M., C. Piroddi, J. Steenbeek, K. Kaschner, et al. 2010. "The Biodiversity of the Mediterranean Sea: Estimates, Patterns, and Threats." *PLoS ONE* 5, no. 8: e11842. https://doi.org/10.1371/journal.pone.0011842.

Chen, S., Z. Zhang, Y. Cai, et al. 2022. "Length–Weight Relationships of Five Fish Species From the Angqu River, China." *Lakes & Reservoirs: Science, Policy and Management for Sustainable Use* 27, no. 3: 12409. https://doi.org/10.1111/lre.12409.

Cheng, M. L., D. R. Goethel, P. J. F. Hulson, M. J. Wilberg, C. Marsh, and C. J. Cunningham. 2025. "Misspecifying Sex-Structured Dynamics in Stock Assessment Models." *Fish and Fisheries* 26: 454–472. https://doi.org/10.1111/faf.12891.

de Morais, L., A. Sidib ´, F. Nuno, et al. 2015. *Lutjanus fulgens. IUCN Red List of Threatened Species*, e.T194389A2329339. https://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T194389A2329339.en.

Directorate of Fisheries—Democratic Republic of São Tomé and Príncipe. 2015. *Report of the Follow-up Study of Demersal Species in the Coastal Zone of São Tomé and Príncipe*.

Directorate of Fisheries—Democratic Republic of São Tomé and Príncipe. 2019. *Statistical Bulletin of the Estimated Catch Data of the Main Artisanal Fishing Species*.

Environmental Defense Fund. 2023. *Linking Knowledge and Action for Climate-Ready Fisheries: Putting the Puzzle Together*. https://blogs.edf.org/edfish/2023/07/25/linking-knowledge-and-action-for-climate-ready-fisheries-putting-the-puzzle-together/.

Food and Agriculture Organization. 2021. *Blue Economy Transition Strategy for São Tomé and Principe*. https://openknowledge.fao.org/handle/20.500.14283/cb5913pt.

Fakoya, K. A., M. A. Anetekhai, and A. O. Saba. 2020. "Length-Weight Relationship and Relative Condition Factor of Gorean Snapper, *Lutjanus goreensis* (Valenciennes, 1830) in the Coastal Zone of Lagos, South-West Nigeria." *The Zoologist* 17: 20–25. https://doi.org/10.4314/tzool.v17i1.4.

Fulton, T. W. 1904. *The Sovereignty of the Sea: An Historical Account of the Claims of England to the Dominion of the British Seas, and of the Evolution of the Territorial Waters*. W. Blackwood.

Falsone, F., M. L. Geraci, D. Scannella, et al. 2022. "Relationships Between Length and Weight of 52 Species From the South of Sicily (Central Mediterranean Sea)." *Fishes* 7, no. 2: 92. https://doi.org/10.3390/fishes7020092.

Froese, R. 2006. "Cube Law, Condition Factor and Weight–Length Relationships: History, Meta-Analysis, and Recommendations." *Journal of Applied Ichthyology* 22: 241–253. https://doi.org/10.1111/j.1439-0426.2006.00805.x.

Froese, R. and Pauly, D., eds. 2025. *FishBase* (version 04/2025). World Wide Web electronic publication. http://www.fishbase.org.

Hsieb, H. E., E. Mohammed-AbdAllah, and R. E. M. Said. 2024. "Age and Growth of the Blackspot Snapper *Lutjanus ehrenbergii* (Family: Lutjanidae), From the Red Sea and the Arabian Gulf." *Egyptian Journal of Aquatic Biology & Fisheries* 28, no. 4: 1115–1132. https://doi.org/10.21608/ejabf.2024.372836.

Jebarani, R. T., T. Mohanraj, M. Srinivasan, and C. Shunmugavel. 2021. "Length–Weight Relationship and Condition Factor of *Lethrinus nebulosus* (Forsskål, 1775) and *Lethrinus microdon* (Valenciennes, 1830) Along Thoothukudi Coast, Gulf of Mannar." *Journal of the Marine Biological Association of India* 63, no. 1: 79–84. https://doi.org/10.6024/jmbai.2021.63.1.2240-12.

Jisr, N., G. Younes, C. Sukhn, and M. H. El-Dakdouki. 2018. "Length–Weight Relationships and Relative Condition Factor of Fish That Inhabit the Marine Area of the Eastern Mediterranean City, Tripoli-Lebanon." *The Egyptian Journal of Aquatic Research* 44, no. 4: 299–305. https://doi.org/10.1016/j.ejar.2018.11.004.

Jobling, M. 2002. "Environmental Factors and Rates of Development and Growth." In *Handbook of Fish Biology and Fisheries*, edited by P. J. B. Hart, and J. D. Reynolds, 97–122 John Wiley & Sons, Ltd. https://doi.org/10.1002/9780470693803.ch5.

Jurado-Ruzafa, A., and C. Hernández-González. 2024. "Length–Weight Relationships for Seven Fish Species Caught off Northwest Africa." Journal of the Marine Biological Association of the United Kingdom 104: e36, 1–5. https://doi.org/10.1017/S0025315424000298.

Konney, A. S. K., C. Nii, A. Selasi, and H. Samuel. 2023. "Growth, Mortality and Exploitation Rates of *Lethrinus atlanticus* in the Marine Waters of Ghana, West Africa." *Bio-Research* 21, no. 1: 2705–3822. https://doi.org/10.4314/br.v21ix.x.

Kendall, N., and T. Quinn. 2012. "Quantifying and Comparing Size Selectivity Among Alaskan Sockeye Salmon Fisheries." *Ecological Applications* 22, no. 3: 804–816. https://doi.org/10.1890/11-1189.1.

Kumar, G., A. Kashyap, and M. Serajuddin. 2023. "Length–Weight Relationships and Condition Factor of Asian Sheat Catfish, *Wallago attu* (Bloch & Schneider, 1801) Inhabiting Different Rivers of India." *Journal of Fisheries* 11, no. 1: 111–203. https://doi.org/10.17017/j.fish.450.

Lal, M., N. T. Narejo, M. H. Chandio, et al. 2023. "Analysis of Length and Weight of Five Dominant Fish Species From Nurri Lake District Badin, Sindh, Pakistan." *Sarhad Journal of Agriculture* 39, no. 2: 452–456. https://dx.doi.org/10.17582/journal.sja/2023/39.2.452.456.

Levene, H. 1960. "Robust Tests for Equality of Variances." In *Contributions to Probability and Statistics: Essays in Honor of Harold Hotelling*, Edited by I. Olkin. Stanford University Press.

Lidour, K., J. Vorenger, and P. Béarez. 2018. "Size and Weight Estimations of the Spangled Emperor (*Teleostei: Lethrinidae: Lethrinus nebulosus*) From Bone Measurements Elucidate the Fishing Grounds Exploited and Ancient Seasonality at Akab (United Arab Emirates)." *International Journal of Osteoarchaeology* 28: 681–694. https://doi.org/10.1002/oa.2683.

Masri, M. M. 2023. "Study of Reproductive Biology, Growth and Mechanism of Sexual Inversion in the Fish Species of the Genus *Dentex* (Family: Sparidae) in Syrian Marine Waters." *AGRIS* 95, no. 6. https://agris.fao.org/search/en/providers/122526/records/65a63c14b48850e523516f29.

Mahé, K., J. Baudrier, A. Larivain, et al. 2023. "Morphometric Relationships Between Length and Weight of 109 Fish Species in the Caribbean Sea (French West Indies)." *Animals* 13: 3852. https://doi.org/10.3390/ani13243852.

Mohdeb, R., and H. Kara. 2014. "Age, Growth and Reproduction of the Morocco Dentex *Dentex maroccanus* of the Eastern Coast of Algeria." *Journal of the Marine Biological Association of the United Kingdom* 95, no. 6: 1261–1270. https://doi.org/10.1017/S0025315414001945.

Morton, A., and R. D. Routledge. 2006. "Fulton's Condition Factor: Is It a Valid Measure of Sea Lice Impact on Juvenile Salmon?" *North American Journal of Fisheries Management* 26, no. 1: 56–62. https://doi.org/10.1577/M05-068.1.

Oliveira, M. T., M. N. Santos, R. Coelho, V. Monteiro, A. Martins, and P. G. Lino. 2015. "Weight–Length and Length–Length Relationships for Reef Fish Species From the Cape Verde Archipelago (Tropical North-Eastern Atlantic)." *Journal of Applied Ichthyology* 31, no. 1: 236–241.

Omogoriola, H. O., A. B. Willams, O. M. Adegbile, F. C. Olakolu, S. U. Ukaonu, and E. F. Myade. 2011. "Length-Weight Relationships, Condition Factor (K) and Relative Condition Factor (Kn) of Sparids, *Dentex congoensis* (Maul, 1954) and *Dentex angolensis* (Maul and Poll, 1953), in Nigerian Coastal Water." *International Journal of Biological and Chemical Sciences* 5, no. 2: 739–747. https://doi.org/10.4314/ijbcs.v5i2.72147.

Ogle, D. H., J. C. Doll, A. P. Wheeler, and A. Dinno. 2025. *FSA: Simple Fisheries Stock Assessment Methods* (Version 0.9.6) [R package]. https://doi.org/10.32614/CRAN.package.FSA.

Olopade, O. A., and H. E. Dienye. 2018. "Abundance, Length-Weight Relationship and Condition Factor of Lutjanids (Snapper) From Sombreiro

River, Nigeria." *Punjab University Journal of Zoology* 33, no. 1–2: 77–84. https://doi.org/10.17582/pujz/2018.33.1.42.46.

Palomares, M. L. D., R. Froese, B. Derrick, et al. 2020. "Fishery Biomass Trends of Exploited Fish Populations in Marine Ecoregions, Climatic Zones and Ocean Basins." *Estuarine, Coastal and Shelf Science* 243: 106896. https://doi.org/10.1016/j.ecss.2020.106896.

Porriños, G. 2021. *Characterisation of Artisanal Fisheries in São Tomé and Príncipe Through Participatory, Smartphone-Based Landing Surveys*. http://www.gporrinos.com/uploads/1/0/8/7/108752045/porrinos_2021_stp_small_scale_fisheries.pdf.

Porriños, G., K. Metcalfe, A. Nuno, et al. 2024. "Fish Community Composition in the Tropical Archipelago of São Tomé and Príncipe." *PLoS ONE* 19, no. 11: e0312849. https://doi.org/10.1371/journal.pone.0312849.

Ragheb, E. 2023. "Length–Weight Relationship and Well-Being Factors of 33 Fish Species Caught by Gillnets From the Egyptian Mediterranean Waters off Alexandria." *Egyptian Journal of Aquatic Research* 49, no. 3: 361–367. https://doi.org/10.1016/j.ejar.2023.01.001.

Rajitha, B. T., and P. M. Pillai. 2015. "Estimation of Length–Weight Relationship of Six Coral Reef Fishes of Order Perciformes From Gulf of Mannar, Southeast Coast of India." *International Journal of Fisheries and Aquatic Studies* 3, no. 1: 305–307.

Razi, A., and A. Noori. 2018. "Length–Weight, Condition Factor and Gonadosomatic Index of Blackspot Snapper, *Lutjanus Fulviflamma* (Forsskal, 1775) (Perciformes: Lutjanidae) in the Northern Persian Gulf." *International Journal of Aquatic Biology* 6, no. 2: 66–74.

Rodríguez-García, C., J. Castro-Gutiérrez, R. Domínguez-Bustos, A. García-González, and R. Cabrera-Castro. 2023. "Every Fish Counts: Challenging Length–Weight Relationship Bias in Discards." *Fishes* 8, no. 5: 222. https://doi.org/10.3390/fishes8050222.

Sangun, L., E. Akamca, and M. Akar. 2007. "Weight–Length Relationships for 39 Fish Species From the North-Eastern Mediterranean Coast of Turkey." *Turkish Journal of Fisheries and Aquatic Sciences* 7: 37–40. https://www.trjfas.org/uploads/pdf_310.pdf.

Santos, M. N., M. T. Oliveira, and J. Cúrdia. 2013. "A Comparison of the Fish Assemblages on Natural and Artificial Reefs off Sal Island (Cape Verde)." *Journal of the Marine Biological Association of the United Kingdom* 93, no. 2: 437–452. https://doi.org/10.1017/S0025315412001051.

Singh, M. K., S. Sonowal, and C. Saikia. 2022. "A Study on Length–Weight Relationship and Condition Factor of Three Important Freshwater Fish Species of Maijan Beel, Dibrugarh, Assam, India." *Asian Journal of Biological and Life Sciences* 10, no. 3: 662–666. https://doi.org/10.5530/ajbls.2021.10.88.

Soykan, O., A. T. Ilkyaz, G. Metin, and H. T. Kinacigil. 2015. "Growth and Reproduction of *Boops boops*, *Dentex macrophthalmus*, *Diplodus vulgaris*, and *Pagellus Acarne* (Actinopterygii: Perciformes: Sparidae) From East-Central Aegean Sea, Turkey." *Acta Ichthyologica et Piscatoria* 45, no. 1: 39–55. https://doi.org/10.3750/AIP2015.45.1.05.

Tu, C. Y., K. T. Chen, and C. Hsieh. 2018. "Fishing and Temperature Effects on the Size Structure of Exploited Fish Stocks." *Scientific Reports* 8: 7132. https://doi.org/10.1038/s41598-018-25403-x.

Van, A., A. Gümüş, and S. Süer. 2019. "Weight Relationships and Condition Factors of 15 Fish Species From Kizilirmak-Yesilirmak Shelf Area, the Southeastern Black Sea." *NE Sciences* 4, no. 1: 21–27.

Vinothkumar, R., A. Srinivasan, P. Jawahar, et al. 2022. "Length–Weight Relationship and Condition Factor of *Sphyraena putnamae* Jordan and Seale, 1905 and *Sphyraena obtusata* Cuvier, 1829 From Pamban Island Waters, Gulf of Mannar, South-East Coast of India." *Indian Journal of Fisheries* 69, no. 1: 162–168. https://doi.org/10.21077/ijf.2022.69.1.115948-18.

Wang, Y., X. Pan, M. Tian, et al. 2024. "The Length–Weight Relationships of Twelve Fish Species From the Heishui River, China." *Journal of Applied Ichthyology* 5: 1–6. https://doi.org/10.1155/2024/6667189.

World Bank. 2023. *World Development Indicators*. https://datatopics.worldbank.org/world-development-indicators/.

Zacarias, W. B. M., R. Kindong, T. Melo, M. G. M. V. G. Cravid, and X. Dai. 2021. "Estimation of the Weight–Length Relationship and Condition Factor of Three Main Fish Species in the Coastal Region of the Southern Zone of São Tomé and Príncipe Island." *International Journal of Fisheries and Aquatic Research* 6, no. 2: 26–33.

Zacarias, W. B. M., X. Dai, R. Kindong, O. Sarr, and A. H. Moussa. 2022. "Analysis of Fishery Resource Management Practices in São Tomé and Príncipe: Perception of the Dynamics of Catches From 1950–2020, Recommendations and Strategies for Future Research." *Sustainability* 14, no. 20: 13367. https://doi.org/10.3390/su142013367.

Zhu, L., D. Yu, M. Reichaed, M. Li, J. Gao, and H. Liu. 2025. "Key Environmental Factors Determining Life History Strategies of River Fishes and Their Historical Changes in the Yangtze River." *Water Biology and Security* 4: 100376. https://doi.org/10.1016/j.watbs.100376.

Supporting Information

Additional supporting information can be found online in the Supporting Information section.

Supplementary Material: aff270164-sup-0001-SuppMat.docx