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# Length–weight relations of 44 fish species (Actinopterygii) inhabiting an unprotected tropical coastal biological corridor of Yucatan, Mexico

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## Abstract

Length–weight relations (LWRs) were estimated for 44 fish species, representing 23 families, collected from an unprotected coastal biological corridor of the Yucatan Peninsula. The following species were studied (in alphabetical order): *Acanthostracion quadricornis* (Linnaeus, 1758); *Albula vulpes* (Linnaeus, 1758); *Anchoa hepsetus* (Linnaeus, 1758); *Anchoa lamprotaenia* Hildebrand, 1943, *Anchoa lyolepis* (Evermann et Marsh, 1900), *Anchoa mitchilli* (Valenciennes, 1848); *Archosargus rhomboidalis* (Linnaeus, 1758); *Ariopsis felis* (Linnaeus, 1766); *Bagre marinus* (Mitchill, 1815); *Bairdiella chrysoura* (Lacepède, 1802); *Caranx latus* Agassiz, 1831; *Chaetodipterus faber* (Broussonet, 1782); *Chriodorus atherinoides* Goode et Bean, 1882; *Cynoscion arenarius* Ginsburg, 1930; *Elops saurus* Linnaeus, 1766; *Eucinostomus argenteus* Baird et Girard, 1855; *Eucinostomus gula* (Quoy et Gaimard, 1824); *Eucinostomus harengulus* Goode et Bean, 1879; *Harengula jaguana* Poey, 1865; *Hyporhamphus unifasciatus* (Ranzani, 1841); *Lagodon rhomboides* (Linnaeus, 1766); *Lutjanus griseus* (Linnaeus, 1758); *Menticirrhus americanus* (Linnaeus, 1758); *Menticirrhus littoralis* (Holbrook, 1847); *Menticirrhus saxatilis* (Bloch et Schneider, 1801); *Mugil curema* Valenciennes, 1836; *Mugil trichodon* Poey, 1875; *Oligoplites saurus* (Bloch et Schneider, 1801); *Opisthonema oglinum* (Lesueur, 1818); *Opsanus beta* (Goode et Bean, 1880); *Orthopristis chrysoptera* (Linnaeus, 1766); *Prionotus tribulus* Cuvier, 1829; *Rypticus maculatus* Holbrook, 1855; *Selene vomer* (Linnaeus, 1758); *Sphoeroides spengleri* (Bloch, 1785); *Sphoeroides testudineus* (Linnaeus, 1758); *Strongylura notata* (Poey, 1860); *Strongylura timucu* (Walbaum, 1792); *Symphurus plagiusa* (Linnaeus, 1766); *Synodus foetens* (Linnaeus, 1766); *Trachinotus carolinus* (Linnaeus, 1766); *Trachinotus falcatus* (Linnaeus, 1758); *Trachinotus goodei* Jordan et Evermann, 1896; *Urobatis jamaicensis* (Cuvier, 1816). A new maximum standard length (SL) was recorded for *Anchoa lamprotaenia*. Positive allometric growth was reported in ten species, negative allometric growth in sixteen species, and isometric growth in eighteen species.

## Keywords

Length–weight relations, nursery habitats, wetlands, Yucatan Peninsula

## Introduction

Length–weight relations (LWRs) of fishes are a key element for the study of their biology, taxonomy, physiology, ecology (Vega-Cendejas et al. 2017), and fish population dynamics (Kohler et al. 1995). They are useful to calculate the expected weight from the known length of fish and vice versa (Xie et al. 2015; Kuriakose 2017), to estimate the isometric or allometric growth (Teixeira-de Mello et al. 2006), as an indicator of fatness and the relative well-being of the fish population, the standing stock biomass and comparing the ontogeny of fish populations from different regions (Petrakis and Stergiou 1995). This relation has also been used for species-specific life history comparisons between regions (Wotton 1990), and evaluations of parasite effects (Teixeira-de Mello and Eguren 2008).

The presently reported study was an effort to determine LWRs for 44 fish species from Yucatan, southern Gulf of Mexico. The fish were collected from a chain of unprotected littoral habitats which we will later refer to as the Yucatan Coastal Biological Corridor (YCBC). A biological corridor is a delimited geographic space that promotes connectivity between landscapes, ecosystems, and natural or modified habitats and ensures the maintenance of biological diversity and ecological processes. It also allows genetic exchange between fragmented populations and the integration of these areas into land use planning plans. Studying these areas provides valuable information to propose new locations that require protection, as well as to identify high-priority network linkages between existing marine protected areas (Pendoley et al. 2014) and to define essential habitats for target species (Turk-Boyer et al. 2014).

Biological corridors emerge as a mechanism that attempts to give greater variability to the conservation of species found in wild areas, allowing the movement of biota from one protected area to another or between fragments of ecosystems (Moran et al. 2019). The YCBC unites ecologically protected natural areas through regions with various productive activities and different land uses. Its importance lies in the fact that this system is unique in the association of the species with the habitat and its ecological process, in the way in which the populations that inhabit the coast using their natural resources. This area has been recognized for having great biodiversity, characterized by the heterogeneity of its habitats with the presence of wetlands, coastal lagoons, and petenes on its coastline. However, the YCBC, which stretches 128 km, has been modified by various anthropogenic activities such as the construction of docks and ports, as well as by artisanal and industrial fishing, aquaculture, and ecotourism (Herrera-Silveira and Morales-Ojeda 2009). Studies in this area have indicated that diversity and abundance of fishery resources increase inside protected areas. However, the surrounding unprotected areas require strategies to allow the free flow of species from one protected area to the other (Palacios-Sánchez et al. 2019).

## Material and methods

The YCBC, as part of the Mesoamerican Corridor is located in the tropical region of the southeastern Gulf of Mexico (21°02′48.66″–21°21′28.20″W, 89°07′8.04″–90°16′45.84″N), which includes 350 km of costal zone habitats (Euán-Avila et al. 2014) and connects two important reserves in the Yucatan Peninsula—Celestun in the West and Ria Lagartos in the East (Palacios-Sánchez et al. 2019) (Fig. 1).

Sampling of the fish specimens was carried out monthly for three years (October 2001 through April 2004) in 24 localities of the YCBC. Fish samples were collected during the first six hours of light of the day using a benthic trawling net (15 m long × 1.5 m, 2.54 cm mesh) in all the habitats (wetlands, coastal lagoons, coastline). At each station, to carry out sampling, we walked perpendicular

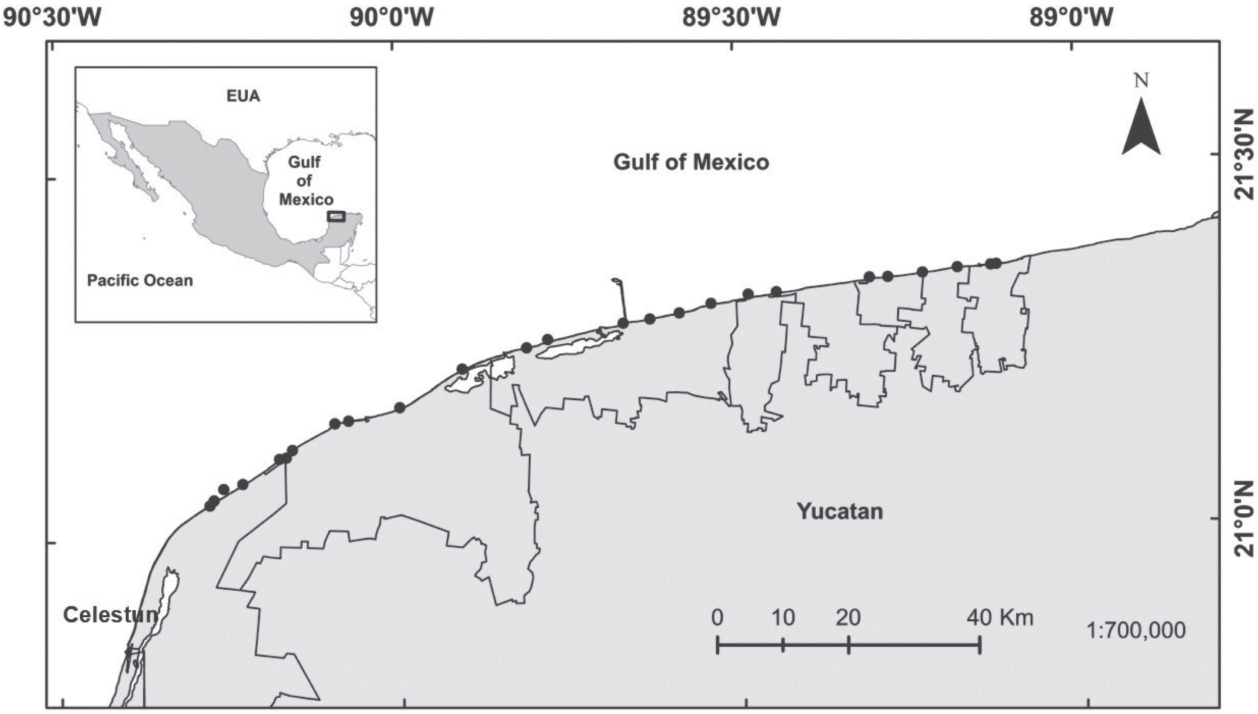


**Figure 1.** Sampling stations in the study area in the unprotected Yucatan Coastal Biological Corridor, southern Gulf of Mexico.

to the coast, measuring the distance from the shore to record the sampled area. The trawl net was dragged manually, making two replicates per station, separated by 10 m. Collected fishes were euthanized in ice slurry, preserved (70% ethanol), and transported to the laboratory where they were identified using specialized references (Allen 1985; Carpenter 2002a, 2002b; McEachran and Fechhelm 1998, 2005, among others), measured for standard length (SL) (to the nearest 0.1 cm), and weighed (to the nearest 0.01 g). A representative sample of each species was deposited and cataloged in the Ichthyology Collection of the Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional, Mérida, Mexico (CINV-NEC), reference number YUC-PEC.084.0999.

We calculated the LWRs using the allometric formula

$$W = aL^b$$

where $W$ is the weight of the fish [g], $L$ is the standard length [cm], $a$ is the intercept, and $b$ is the allometric coefficient/slope. The values of $a$ and $b$ were calculated with Statgraphics software (Centurion XV, Version 15.1.02, Copyright 1982–2006 StatPoint, Inc.) with a linear least squares regression using a logarithmic scale. Based on the value of the slope ($b$), the growth of a fish species was considered negative allometric ($b < 3$), positive allometric ($b > 3$), or isometric ($b = 3$) (Froese et al. 2011). Outliers were removed using logarithmic plots, and limits for $a$ and $b$ were estimated by a student's $t$-test with a 95% confidence (Froese 2006). In some cases, when the number of specimens was too small or the size range was too narrow to estimate the LWRs parameters $a$ and $b$, we assumed an isometric relation ($b = 3$) (Froese 2006; Hay et al. 2020) and the value of the intercept $a$ will be obtained with the following formula:

$$a = \frac{\sum_{i=1}^{n} \frac{W}{L^3}}{n}$$

where $W$ refers to the weight [g], $L$ to the standard length [cm], and $n$ to the number of specimens.

## Results

The descriptive statistics and the estimated LWRs parameters for 44 species which represents 23 families are summarized in Table 1, including *Urobatis jamaicensis* (Cuvier, 1816) [Urotrygonidae]; *Albula vulpes* (Linnaeus, 1758) [Albulidae]; *Elops saurus* Linnaeus, 1766 [Elopidae]; *Anchoa hepsetus* (Linnaeus, 1758), *Anchoa lamprotaenia* Hildebrand, 1943, *Anchoa lyolepis* (Evermann et Marsh, 1900), *Anchoa mitchilli* (Valenciennes, 1848) [Engraulidae]; *Harengula jaguana* Poey, 1865, *Opisthonema oglinum* (Lesueur, 1818) [Dorosomatidae]; *Ariopsis felis* (Linnaeus, 1766), *Bagre marinus* (Mitchill, 1815) [Ariidae]; *Synodus foetens* (Linnaeus, 1766) [Synodontidae]; *Opsanus beta* (Goode et Bean, 1880) [Batrachoididae]; *Mugil curema* Valenciennes, 1836, *Mugil trichodon* Poey, 1875 [Mugilidae]; *Strongylura notata* (Poey, 1860), *Strongylura timucu* (Walbaum, 1792) [Belonidae]; *Chriodorus atherinoides* Goode et Bean, 1882, *Hyporhamphus unifasciatus* (Ranzani, 1841) [Hemiramphidae]; *Caranx latus* Agassiz, 1831, *Oligoplites saurus* (Bloch et Schneider, 1801), *Selene vomer* (Linnaeus, 1758), *Trachinotus carolinus* (Linnaeus, 1766), *Trachinotus falcatus* (Linnaeus, 1758), *Trachinotus goodei* Jordan et Evermann, 1896 [Carangidae]; *Symphurus plagiusa* (Linnaeus, 1766) [Cynoglossidae]; *Eucinostomus argenteus* Baird et Girard, 1855, *Eucinostomus gula* (Quoy et Gaimard, 1824), *Eucinostomus harengulus* Goode et Bean, 1879 [Gerreidae]; *Rypticus maculatus* Holbrook, 1855 [Grammistidae]; *Orthopristis chrysoptera* (Linnaeus, 1766) [Haemulidae]; *Lutjanus griseus* (Linnaeus, 1758) [Lutjanidae]; *Prionotus tribulus* Cuvier, 1829 [Triglidae]; *Chaetodipterus faber* (Broussonet, 1782) [Ephippidae]; *Bairdiella chrysoura* (Lacepède, 1802), *Cynoscion arenarius* Ginsburg, 1930, *Menticirrhus littoralis* (Holbrook, 1847), *Menticirrhus americanus* (Linnaeus, 1758), *Menticirrhus saxatilis* (Bloch et Schneider, 1801) [Sciaenidae]; *Archosargus rhomboidalis* (Linnaeus, 1758), *Lagodon rhomboides* (Linnaeus, 1766) [Sparidae]; *Acanthostracion quadricornis* (Linnaeus, 1758) [Ostraciidae]; *Sphoeroides spengleri* (Bloch, 1785), *Sphoeroides testudineus* (Linnaeus, 1758) [Tetraodontidae].

All LWRs estimates were statistically significant ($P < 0.05$). New maximum lengths are reported for one species *Anchoa lamprotaenia* (12.2 cm SL). The scaled herring, *Harengula jaguana*, was the most abundant fish species (3769 specimens), followed by the broad-striped anchovy, *Anchoa hepsetus* (3559 specimens). However, even though the sampling continued for three years, a lower number of specimens was obtained (10–12 specimens) for some of the species (*Urobatis jamaicensis*, *Bagre marinus*, *Mugil curema*, *Strongylura timucu*, *Selene vomer*, *Rypticus maculatus*, *Prionotus tribulus*, *Chaetodipterus faber*), due to their low abundance and occurrence in these coastal ecosystems. Estimates of $a$ and $b$ for the LWRs, the coefficient of determination $R^2$, and 95% confidence limits for $b$ are given in Table 1. A negative allometric growth was recorded in 16 species, a positive allometric growth in 10 species, and isometric growth in 18 species.

## Discussion

The coefficient of determination ($R^2$) ranged from 0.861 (*Anchoa hepsetus*) to 0.996 (*Albula vulpes*, *Archosargus rhomboidalis*). This low value is related to the high dispersion of the length data. It is important also to mention that the length range of specimens is not the only magnitude that influences the value of $R^2$. Other factors such as the size of the sample, the length of the specimens, the gonad maturity, and diet are of importance. The exact relation between length and weight differs among species according to their inherited body shape, and within a species according to the condition (robustness) of individual fish. The condition fac-

**Table 1.** Length–weight relations for 44 species of the unprotected Yucatan Coastal Biological Corridor, Mexico.

| Species | *n* | SL [cm] | Weight [g] | *a* | CI 95% *a* | *b* | CI 95% *b* | Growth type | $R^2$ | Reference data | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | $L_m$ [cm] | $L_{max}$ [cm] |
| Urotrygonidae | | | | | | | | | | | |
| *Urobatis jamaicensis* | 10 | 12.5–29.9 | 22.0–239.9 | 0.010 | 0.009–0.0011 | 3.000 | — | I | — | $20.0_{TL, 1}$ | $76.0_{TL}$ |
| Albulidae | | | | | | | | | | | |
| *Albula vulpes* | 13 | 3.2–13.1 | 0.3–32.8 | 0.008 | 0.006–0.010 | 3.229 | 3.085–3.373 | +A | 0.996 | $21.0_{FL}$ | $104.0_{TL}$ |
| Elopidae | | | | | | | | | | | |
| *Elops saurus* | 20 | 12.7–31.5 | 24.1–196.5 | 0.007 | 0.006–0.008 | 3.000 | — | I | — | $32.5_{SL}$ | $100.0_{TL}$ |
| Engraulidae | | | | | | | | | | | |
| *Anchoa hepsetus* | 3559 | 3.4–6.7 | 0.4–2.4 | 0.019 | 0.018–0.020 | 2.508 | 2.475–2.542 | –A | 0.861 | $4.3_{TL, 2}$ | $15.3_{TL}$ |
| ***Anchoa lamprotaenia*** | 360 | **2.9–12.2** | 0.12–34.5 | 0.005 | 0.005–0.006 | 3.315 | 3.278–3.352 | +A | 0.989 | $5.0_{SL, 3}$ | $12.0_{TL}$ |
| *Anchoa lyolepis* | 39 | 3.9–6.3 | 0.5–2.2 | 0.009 | 0.008–0.009 | 3.000 | — | I | — | $8.2_{SL, 28}$ | $12.0_{TL}$ |
| *Anchoa mitchilli* | 1232 | 2.3–6.1 | 0.1–2.4 | 0.009 | 0.009–0.010 | 2.999 | 2.944–3.055 | –A | 0.905 | $4.0_{SL, 4}$ | $10.0_{TL}$ |
| Dorosomatidae | | | | | | | | | | | |
| *Harengula jaguana* | 3769 | 2.1–12.8 | 0.1–36.3 | 0.008 | 0.007–0.008 | 3.381 | 3.366–3.397 | +A | 0.979 | $8.0_{SL, 5}$ | $21.2_{TL}$ |
| *Opisthonema oglinum* | 92 | 3.8–17.1 | 0.8–86.2 | 0.011 | 0.009–0.012 | 3.122 | 3.020–3.224 | +A | 0.976 | $11.5_{FL}$ | $38.0_{TL}$ |
| Ariidae | | | | | | | | | | | |
| *Ariopsis felis* | 1388 | 4.0–26.3 | 0.9–240.7 | 0.016 | 0.015–0.017 | 2.948 | 2.924–2.972 | –A | 0.977 | $15.0_{SL, 6}$ | $70.0_{TL}$ |
| *Bagre marinus* | 12 | 7.2–15.3 | 5.0–50.2 | 0.015 | 0.014–0.016 | 3.000 | — | I | — | $32.8_{FL, 8}$ | $100_{TL, 7}$ |
| Synodontidae | | | | | | | | | | | |
| *Synodus foetens* | 52 | 3.9–41.4 | 0.4–166.0 | 0.016 | 0.011–0.022 | 2.751 | 2.620–2.882 | –A | 0.974 | $19.0_{SL}$ | $53.8_{TL}$ |
| Batrachoididae | | | | | | | | | | | |
| *Opsanus beta* | 23 | 4.5–10.4 | 1.9–24.8 | 0.012 | 0.007–0.019 | 3.301 | 3.032–3.571 | +A | 0.972 | $7.6_{SL}$ | $32.4_{SL, 9}$ |
| Mugilidae | | | | | | | | | | | |
| *Mugil curema* | 10 | 2.0–23.9 | 0.1–153.4 | 0.016 | 0.014–0.018 | 3.000 | — | I | — | $16.4_{TL, 10}$ | $91.0_{TL}$ |
| *Mugil trichodon* | 20 | 2.1–15.3 | 0.1–64.6 | 0.013 | 0.009–0.018 | 3.180 | 3.034–3.326 | +A | 0.991 | $16.0_{FL}$ | $46.0_{TL}$ |
| Belonidae | | | | | | | | | | | |
| *Strongylura notata* | 104 | 24.0–46.0 | 23.7–124.8 | 0.009 | 0.005–0.015 | 2.524 | 2.364–2.683 | –A | 0.909 | $22.6_{TL}$ | $61.0_{TL}$ |
| *Strongylura timucu* | 10 | 7.2–36.5 | 0.3–72.0 | 0.0012 | 0.001–0.0014 | 3.000 | — | I | — | — | $61.0_{TL}$ |
| Hemiramphidae | | | | | | | | | | | |
| *Chriodorus atherinoides* | 36 | 3.8–17.8 | 0.2–40.2 | 0.008 | 0.005–0.011 | 3.312 | 2.971–3.652 | +A | 0.933 | — | $26.0_{TL}$ |
| *Hyporhamphus unifasciatus* | 173 | 5.0–25.5 | 0.4–86.7 | 0.003 | 0.003–0.0033 | 3.000 | — | I | — | $18.5_{FL, 28}$ | $30.0_{TL}$ |
| Carangidae | | | | | | | | | | | |
| *Caranx latus* | 14 | 7.0–14.9 | 7.5–82.0 | 0.021 | 0.020–0.022 | 3.000 | — | I | — | $37.0_{FL}$ | $101.0_{FL}$ |
| *Oligoplites saurus* | 28 | 2.2–23.8 | 0.1–145.3 | 0.010 | 0.010–0.011 | 3.000 | — | I | — | $19.8_{SL, 11}$ | $42.5_{SL, 13}$ |
| *Selene vomer* | 11 | 2.3–9.2 | 0.4–23.4 | 0.049 | 0.031–0.079 | 2.700 | 2.374–3.025 | –A | 0.982 | $24.1_{TL, 29}$ | $48.3_{TL}$ |
| *Trachinotus carolinus* | 123 | 1.5–9.5 | 0.5–20.7 | 0.026 | 0.025–0.027 | 3.000 | — | I | — | $25.0_{FL, 12}$ | $64.0_{TL}$ |
| *Trachinotus falcatus* | 491 | 2.0–14.5 | 0.4–104.1 | 0.045 | 0.042–0.049 | 2.850 | 2.800–2.900 | –A | 0.963 | $48.6_{FL}$ | $122.0_{TL}$ |
| *Trachinotus goodei* | 34 | 2.8–16.9 | 0.8–119.4 | 0.029 | 0.021–0.041 | 2.927 | 2.778–3.078 | –A | 0.983 | $26.0_{TL, 12}$ | $50.0_{TL}$ |
| Cynoglossidae | | | | | | | | | | | |
| *Symphurus plagiusa* | 14 | 7.5–14.4 | 3.6–28.7 | 0.009 | 0.008–0.009 | 3.000 | — | I | — | $10.1_{TL}$ | $21.0_{TL}$ |
| Gerreidae | | | | | | | | | | | |
| *Eucinostomus argenteus* | 347 | 2.0–14.5 | 0.2–45.1 | 0.022 | 0.020–0.024 | 3.006 | 2.954–3.058 | I | 0.975 | $12.0_{TL, 14}$ | $21.2_{TL}$ |
| *Eucinostomus gula* | 388 | 2.6–9.1 | 0.4–20.7 | 0.016 | 0.015–0.018 | 3.219 | 3.161–3.277 | +A | 0.970 | $9.0_{FL, 14}$ | $25.5_{TL}$ |
| *Eucinostomus harengulus* | 19 | 5.5–8.2 | 3.0–12.5 | 0.021 | 0.019–0.022 | 3.000 | — | I | — | $12.0_{SL}$ | $15.0_{SL}$ |
| Grammistidae | | | | | | | | | | | |
| *Rypticus maculatus* | 10 | 6.4–8.9 | 5.2–13.6 | 0.019 | 0.018–0.020 | 3.000 | — | I | — | $8.9_{TL, 16}$ | $24.0_{TL, 15}$ |
| Haemulidae | | | | | | | | | | | |
| *Orthopristis chrysoptera* | 15 | 4.2–20.5 | 1.5–158.7 | 0.022 | 0.021–0.023 | 2.844 | 2.601–3.086 | –A | 0.992 | $20.0_{SL}$ | $46.0_{FL}$ |
| Lutjanidae | | | | | | | | | | | |
| *Lutjanus griseus* | 42 | 4.8–18.5 | 2.9–128.4 | 0.034 | 0.025–0.045 | 2.891 | 2.766–3.015 | –A | 0.984 | $18.0_{SL, 17}$ | $89.0_{TL}$ |
| Triglidae | | | | | | | | | | | |
| *Prionotus tribulus* | 10 | 2.6–14.3 | 0.6–61.6 | 0.026 | 0.024–0.028 | 3.000 | — | I | — | $8.4_{TL, 18}$ | $35.0_{TL}$ |
| Ephippidae | | | | | | | | | | | |
| *Chaetodipterus faber* | 10 | 2.8–7.4 | 1.5–23.8 | 0.064 | 0.060–0.068 | 3.000 | — | I | — | $9.9_{TL, 19}$ | $91.0_{TL}$ |
| Sciaenidae | | | | | | | | | | | |
| *Bairdiella chrysoura* | 114 | 3.3–17.7 | 0.7–111.2 | 0.021 | 0.018–0.024 | 2.966 | 2.909–3.022 | –A | 0.990 | $9.1_{SL, 20}$ | $30.0_{TL}$ |
| *Cynoscion arenarius* | 64 | 2.6–20.9 | 0.3–109.3 | 0.018 | 0.015–0.021 | 2.914 | 2.853–2.976 | –A | 0.994 | $14.0_{SL, 21}$ | $63.5_{TL}$ |
| *Menticirrhus littoralis* | 69 | 2.6–15.7 | 0.2–63.2 | 0.014 | 0.012–0.017 | 2.943 | 2.856–3.031 | –A | 0.984 | $19.8_{TL, 23}$ | $60.0_{SL, 22}$ |
| *Menticirrhus americanus* | 104 | 2.4–14.8 | 0.2–57.3 | 0.010 | 0.009–0.012 | 3.149 | 3.093–3.206 | +A | 0.992 | $15.0_{TL, 24}$ | $60.0_{TL, 25}$ |
| *Menticirrhus saxatilis* | 57 | 2.5–19.0 | 0.4–102.2 | 0.014 | 0.012–0.017 | 2.997 | 2.908–3.086 | –A | 0.986 | $25.6_{TL}$ | $46.0_{TL}$ |

Table continues on next page.

**Table 1.** Continued.

| Species | $n$ | SL [cm] | Weight [g] | $a$ | CI 95% $a$ | $b$ | CI 95% $b$ | Growth type | $R^2$ | Reference data $L_m$ [cm] | Reference data $L_{max}$ [cm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sparidae | | | | | | | | | | | |
| *Archosargus rhomboidalis* | 139 | 2.7–21.0 | 0.5–327.0 | 0.023 | 0.021–0.024 | 3.148 | 3.116–3.179 | +A | 0.996 | $8.0_{SL}$ | $33.0_{TL}$ |
| *Lagodon rhomboides* | 230 | 4.7–13.0 | 2.6–62.4 | 0.041 | 0.032–0.052 | 2.846 | 2.740–2.953 | –A | 0.929 | $8.0_{SL, 26}$ | $40.0_{TL}$ |
| Ostraciidae | | | | | | | | | | | |
| *Acanthostracion quadricornis* | 16 | 12.9–21.7 | 79.9–283.6 | 0.033 | 0.031–0.035 | 3.000 | — | I | — | $19.8_{TL}$ | $55.0_{TL}$ |
| Tetraodontidae | | | | | | | | | | | |
| *Sphoeroides spengleri* | 19 | 3.8–6.3 | 1.7–6.9 | 0.029 | 0.028–0.030 | 3.000 | — | I | — | $18.8_{SL, 28}$ | $30.0_{TL}$ |
| *Sphoeroides testudineus* | 110 | 2.3–20.0 | 3.8–378.7 | 0.055 | 0.039–0.077 | 2.880 | 2.753–3.008 | –A | 0.925 | $10.0_{TL, 27}$ | $38.8_{TL}$ |

$n$ = number of individuals, SL = standard length, TL = total length, $a$ = intercept (equation parameter), $b$ = slope (allometry coefficient), 95% CI = 95% confidence limits (for both equation parameters), $R^2$ = coefficient of determination, $L_m$ = size at first maturity, $L_{max}$ = maximum length. Species in bold denote new maximum length. I = isometric growth, –A = negative allometric growth, +A = positive allometric growth. Isometric growth is assumed in the species with low number of specimens and/or narrow range sizes (no value for 95% CI $b$) (Froese 2006; Hay et al. 2020). Length values without references subscripts comprise information from FishBase. Subscript references: 1 = Yáñez-Arancibia and Amezcua (1979), 2 = Munroe et al. (2015a), 3 = Munroe et al. (2015b), 4 = Vega-Cendejas et al. (2017), 5 = Munroe et al. (2019), 6 = Betancur (2015), 7 = Chao et al. (2015), 8 = Caballero-Chávez (2013), 9 = Collette et al. (2019), 10 = Yago-Bruno et al. (2020), 11 = Duque-Nivia et al. (1995), 12 = Alvarez-Lajonchere and Ibarra Castro (2012), 13 = Ospina-Arango et al. (2008), 14 = Mexicano-Cíntora (1999), 15 = Anderson et al. (2015), 16 = Bullock and Smith (1991), 17 = Allen (1985), 18 = Hoff (1992), 19 = Soeth et al. (2018), 20 = Grammer et al. (2009), 21 = Nemeth et al. (2006), 22 = Chao et al. (2020a), 23 = Aloisio and Nelson (2004), 24 = Chao et al. (2020b), 25 = McEachran and Fechhelm (2005), 26 = Russell et al. (2014), 27 = Shao et al. (2014), 28 = Bouchon-Navaro et al. (2006); 29 = Becerra et al. (2013).

tor sometimes reflects food availability and growth within the weeks before sampling. But the condition is variable and dynamic. Individual fish within the same sample vary considerably, and the average condition of each population varies seasonally and yearly (Kuriakose 2017).

The exponent $b$ presented a mean value of 2.997 (DE: 0.18) with values ranging from 2.508 estimated for *Anchoa hepsetus* to 3.381 for *Harengula jaguana*. The lower values may have resulted from the fact that the majority of the specimens analyzed were juveniles (<4.3 cm) due to their type of habitat (wetlands, petenes, swamps), while in the case of *H. jaguana* it is attributed to its maturity stage. The LWRs parameters of *Rypticus maculatus* (Grammistidae) and *Anchoa lamprotaenia* (Engraulidae) are herein published for the first time in both the scientific literature and databases, such as FishBase (Froese and Pauly 2023) (Table 1). A new maximum length was recorded for *A. lamprotaenia* (12.2 cm SL). Overall, LWRs were highly significant for all species ($P < 0.001$). Changes in $b$ reflect mostly the species morphology and environmental factors such as temperature, salinity, food (quantity, quality, and size), sex, health, and developmental stage (Sparre 1992). In the case of *Sphoeroides testudineus* $a$ (0.055) and $b$ (2.880) were very similar to those previously reported in a hyperhaline coastal lagoon located near this unprotected coastal region (Vega-Cendejas et al. 2017). The number of explanatory variables considered in the model also conditions the value of this coefficient. Carlander (1977) demonstrated that values of $b$ < 2.5 or > 3.5 are often derived from samples with narrow size ranges. The mean condition of specimens as well as the difference in condition between small and large specimens vary between season localities and years, resulting in different weight relations. The influence of extreme values of $b$ on mean $b$ decreases with the number of estimates (Froese 2006).

For species with low numbers or low size ranges (Carlander 1997) (*Urobatis jamaicensis*, *Elops saurus*, *Anchoa lyolepis*, *Bagre marinus*, *Mugil curema*, *Strongylura timucu*, *Chriodorus atherinoide*s, *Hyporhamphus unifasciatus*, *Caranx latus*, *Oligoplites saurus*, *Trachinotus carolinus*, *Symphurus plagiusa*, *Eucinostomus harengulus*, *Rypticus maculatus*, *Prionotus tribulus*, *Chaetodipterus faber*, *Acanthostracion quadricornis*, *Sphoeroides spengleri*), LWRs were calculated assuming $b$ = 3.0, being the value of the slope considered by the formula of Hay et al. (2020).

# Conclusions

The results provided in this study can be very useful for the management of coastal ecosystems, including wetlands, which are required to maintain their diversity due to the increase in human activity in this unprotected coastal region (tourism, fisheries, habitat degradation). Additionally, this information is very useful for the development of trophic models using ECOPATH, which are of significant value in making predictions about the conservation status of this critical habitat for fishery and ecologically important species that use the ecosystem in the juvenile stage.

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