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LENGTH–WEIGHT RELATIONS FOR 20 FISH SPECIES (ACTINOPTERYGII) FROM THE SOUTHERN IONIAN SEA, GREECE

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Abstract. Length–weight relations are presented for 20 fish species caught by small-scale fishery from the southern Ionian Sea (Greece) including a marine protected area from 2013 to 2017. The following species were studied: *Spicara maena* (Linnaeus, 1758); *Labrus merula* Linnaeus, 1758; *Symphodus tinca* (Linnaeus, 1758); *Xyrichtys novacula* (Linnaeus, 1758); *Mullus surmuletus* Linnaeus, 1758; *Phycis phycis* (Linnaeus, 1766); *Sparisoma cretense* (Linnaeus, 1758); *Scorpaena scrofa* Linnaeus, 1758; *Serranus scriba* (Linnaeus, 1758); *Siganus luridus* (Rüppell, 1829); *Diplodus sargus* (Linnaeus, 1758); *Diplodus vulgaris* (Geoffroy Saint-Hilaire, 1817); *Pagellus acarne* (Risso, 1827); *Pagellus erythrinus* (Linnaeus, 1758); *Pagrus pagrus* (Linnaeus, 1758); *Spondyliosoma cantharus* (Linnaeus, 1758); *Dentex dentex* (Linnaeus, 1758); *Synodus saurus* (Linnaeus, 1758); *Trachinus radiatus* Cuvier, 1829; *Uranoscopus scaber* Linnaeus, 1758. The main fishing gears that were involved in the data collection were trammel nets and longlines that were set in the sea during all seasons of the year. A total of 3510 specimens belonging to 12 families were examined. For two species (*Labrus merula* and *Xyrichtys novacula*) the maximum total body length reported in our study was higher than the one reported in the literature. To our knowledge, the length–weight relations for all the 20 fish species are the first to be reported from this area. Thus this contribution can serve as a baseline for monitoring, conservation and management efforts in this region, which is well known for its prime ecological importance.

Keywords: ichthyofauna, morphometric relations, length–weight relation, LWR, marine protected area, Zakynthos

INTRODUCTION

Length–weight relations (LWRs) of fish species constitute a fundamental tool in fisheries biology and management. They have a wide range of applications in fisheries science, such as in converting fish length to biomass as well as on providing information about fish growth type, determining fish condition, comparing growth rates between different areas and supplying data on fish stock assessment models (Froese 2006, Froese et al. 2011). In addition to that, LWRs can be particularly useful when non-destructive sampling techniques, such as underwater visual census and/or digital imaging and video recording, are employed and fish length and abundance are the only available measured data (Chang et al. 2009, Murphy and Jenkins 2010, Holmes et al. 2013). Despite the ecological significance and the prime conservation value of the Greek southern Ionian Sea region regarding cetaceans, monk seals, sea turtles, and endemic fish fauna (Coll et al. 2010, Giakoumi et al. 2013), information regarding LWRs of marine fish fauna is scarce not only in this area but also across the entire Greek Ionian Sea (Liousia et al. 2012), including marine protected areas. Thus, this contribution provides information on LWRs for 20 fish species caught by small-scale fishery operating along the coastline of Zakynthos Island (southern Ionian Sea, Greece) including the marine protected area of the National Marine Park of Zakynthos.

MATERIAL AND METHODS

This study was conducted along the coastline of Zakynthos Island (southern Ionian Sea, Greece), including the marine protected area of the National Marine Park of Zakynthos (NMPZ) (Fig 1). Data were collected with trammel nets (inner mesh size ranging from 21 to 46 mm nominal bar length) and longlines, during all seasons on an annual basis within the frame of several research projects that were implemented between January 2013 and September 2017 (covering at least one sampling survey per month every year). Trammel nets and longlines are the most commonly deployed fishing gears in this area while fishing restrictions in the NMPZ include spatial and seasonal fishing closures for small-scale fishery as well as the prohibition of trawlers, purse seiners, and recreational fishing all year round (Dimitriadis et al. 2018). All specimens were identified down to the species level and measured in the field for total length (TL, in mm) and

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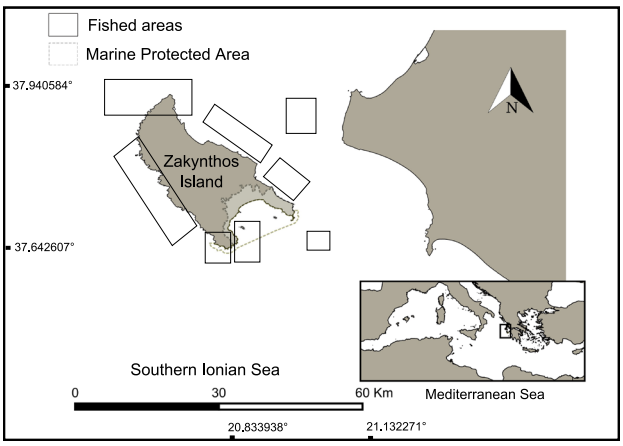

Fig. 1. The sampling locations within the study area (southern Ionian Sea, Greece) including the marine protected area of the National Marine Park of Zakynthos (NMPZ)

body weight (*W*, wet weight; in g). Nomenclature of all the species was based on FishBase (Froese and Pauly 2018). LWRs were estimated using the equation

$$W = aL^b$$

where *W* is total weight (g), *L* is TL (cm), while *a* and *b* are the parameters of the equation (Froese 2006). Before fitting the equation, we plotted the log-transformed TL against the log-transformed *W* and the obvious outliers were removed from the data (Froese 2006). Significant deviation from the isometric growth ($b = 3$, $P < 0.05$) for each species was tested by a modified form of Student's *t*-test (according to Economou et al. 1991, Froese et al. 2011). All analyses were performed using the SPSS v20 software package.

RESULTS

Overall, 3510 specimens from 20 fish species, belonging to 12 families, were examined (Table 1). The following species were studied: *Spicara maena* (Linnaeus, 1758); *Labrus merula* Linnaeus, 1758; *Symphodus tinca* (Linnaeus, 1758); *Xyrichtys novacula* (Linnaeus, 1758); *Mullus surmuletus* Linnaeus, 1758; *Phycis phycis* (Linnaeus, 1766); *Sparisoma cretense* (Linnaeus, 1758); *Scorpaena scrofa* Linnaeus, 1758; *Serranus scriba* (Linnaeus, 1758); *Siganus luridus* (Rüppell, 1829); *Diplodus sargus* (Linnaeus, 1758); *Diplodus vulgaris* (Geoffroy Saint-Hilaire, 1817); *Pagellus acarne* (Risso, 1827); *Pagellus erythrinus* (Linnaeus, 1758); *Pagrus pagrus* (Linnaeus, 1758); *Spondyliosoma cantharus* (Linnaeus, 1758); *Dentex dentex* (Linnaeus, 1758); *Synodus saurus* (Linnaeus, 1758); *Trachinus radiatus* Cuvier, 1829; *Uranoscopus scaber* Linnaeus, 1758. The sample size ranged from 39 individuals for *Labrus merula* to 753 for *Sparisoma cretense*. All LWRs were highly significant ($P < 0.0001$) while the r^2 values ranged from 0.966 (*Xyrichtys novacula*) to 0.986 (*Diplodus vulgaris*) therefore suggesting a strong positive relation between TL and *W*. According to the *t*-test results, four species showed positive allometric growth ($b > 3$; $P < 0.05$), seven species exhibited negative allometric growth ($b < 3$; $P < 0.05$) while the remaining nine species displayed an isometric growth pattern ($b = 3$; $P > 0.05$).

Table 1

Descriptive statistics and estimated parameters of the length–weight relation for 20 species caught in the southern Ionian Sea (Mediterranean Sea, Greece)

Family	Species	*n*	TL [cm]	*W* [g]	*a*	95% CI *a*	*b*	95% CI *b*	r^2	*b* in FishBase	G
Centracanthidae	*Spicara maena*	91	16.0–25.4	50–210	0.016	0.012–0.021	2.923	2.827–3.020	0.976	2.627–3.696	I
Labridae	*Labrus merula*	39	17.1–34.0	73–580	0.011	0.007–0.019	3.057	2.904–3.210	0.978	3.076–3.298	I
	Symphodus tinca	83	12.4–25.3	30–205	0.026	0.020–0.035	2.760	2.664–2.857	0.976	2.721–3.098	–
	Xyrichtys novacula	41	14.6–21.0	46–135	0.011	0.006–0.018	3.075	2.889–3.261	0.966	2.235–3.130	I
Mullidae	*Mullus surmuletus*	566	10.0–32.9	20–423	0.014	0.013–0.016	2.961	2.923–2.999	0.977	2.669–3.512	–
Phycidae	*Phycis phycis*	193	19.0–49.0	55–1550	0.005	0.004–0.006	3.240	3.175–3.304	0.981	2.670–3.188	+
Scaridae	*Sparisoma cretense*	753	13.0–30.6	35–520	0.012	0.010–0.013	3.117	3.080–3.154	0.973	2.976–3.311	+
Scorpaenidae	*Scorpaena scrofa*	335	10.5–39.7	25–1090	0.026	0.023–0.030	2.867	2.823–2.911	0.980	2.730–3.298	–
Serranidae	*Serranus scriba*	123	11.0–24.0	20–175	0.016	0.013–0.020	2.922	2.839–3.005	0.976	2.715–3.409	I
Siganidae	*Siganus luridus*	319	11.9–25.0	25–240	0.031	0.027–0.036	2.736	2.686–2.786	0.973	2.762–3.040	–
Sparidae	*Diplodus sargus*	124	11.0–38.5	22–900	0.011	0.008–0.014	3.145	3.054–3.235	0.975	2.500–3.314	+
	Diplodus vulgaris	56	10.9–29.0	20–400	0.018	0.014–0.024	2.936	2.839–3.033	0.986	2.710–3.590	I
	Pagellus acarne	102	14.6–23.0	40–152	0.014	0.011–0.017	2.975	2.899–3.051	0.984	2.841–3.499	I
	Pagellus erythrinus	172	13.5–47.8	20–1355	0.017	0.014–0.021	2.903	2.834–2.973	0.976	2.428–3.116	–
	Pagrus pagrus	113	12.0–46.0	20–1220	0.021	0.016–0.028	2.888	2.795–2.980	0.972	2.780–3.343	–
	Spondyliosoma cantharus	101	11.0–36.0	20–710	0.014	0.012–0.018	3.028	2.952–3.103	0.985	2.849–3.304	I
	Dentex dentex	53	13.6–70.0	30–4200	0.020	0.013–0.032	2.861	2.731–2.992	0.974	2.987–3.172	–
Synodontinae	*Synodus saurus*	103	15.0–34.0	25–300	0.006	0.005–0.008	3.064	2.978–3.150	0.980	2.715–3.320	I
Trachinidae	*Trachinus radiatus*	91	16.0–25.4	51–210	0.016	0.012–0.021	2.923	2.827–3.020	0.976	2.897–3.125	I
Uranoscopidae	*Uranoscopus scaber*	52	13.4–32.0	34–610	0.011	0.008–0.015	3.134	3.024–3.244	0.985	2.829–3.228	+

n = number of specimens, TL = total length, *W* = weight, *a* = intercept, 95% CI *a* = 95% confidence intervals of *a*, *b* = slope, 95% CI *b* = 95% confidence intervals of *b*; r^2 = coefficient of determination, *b* in FishBase (Froese and Pauly 2018), G = type of growth: – = negative allometric, + = positive allometric, I = isometric.

DISCUSSION

A wide range of lengths was used for all fish species thus ensuring that the examined specimens consisted of both juveniles and adults. However, the presented LWRs estimates should be treated with caution when fish length ranges fall outside the ones reported here. The *b* values ranged from 2.736 for *Siganus luridus* to 3.240 for *Phycis phycis* thus falling within the expected range of 2.5–3.5 (Froese 2006). The *b* values, as well as their 95% confidence intervals for 12 species, were in line with the range reported in FishBase (Froese and Pauly 2018). On the contrary, the upper limit of the 95% confidence intervals of *b* value was higher than the maximum reported *b* value in FishBase for three species (*Xyrichtys novacula*, *Phycis phycis*, *Uranoscopus scaber*) while the lower confidence limit was below the minimum reported *b* value for five species (*Labrus merula*, *Symphodus tinca*, *S. luridus*, *Dentex dentex*, *Trachinus radiatus*). Such differences have been attributed to the interplay of several factors mostly related to the sample size, length range, physiological condition of fish, food availability as well as to area, season and environmental effects (Wootton 1998, Moutopoulos and Stergiou 2002, Froese 2006, Karachle and Stergiou 2008). Regarding *L. merula* and *X. novacula* there are only three available LWRs in FishBase deriving from different regions while the maximum TL reported in our study is higher than the one of previous estimations for both species. Yet this study provides the first LWRs from the Greek southern Ionian Sea for all the reported species and thus it can serve as a tool used for future reference. Our findings may well assist on monitoring, conservation and management efforts in the region and in the marine protected area that it hosts.

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