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ORIGINAL RESEARCH

The length-weight relationship of indigenous and non-indigenous fish species from the small-scale fisheries of Rhodes, Greece

Gerasimos Kondylatos . Ilias Kallias . Dimitris Vafidis . Athanasios Exadactylos . Alexandros Theocharis . Dimitris Mavrouleas . Konstantinos Kalaentzis. Maria Avgoustinaki . Alexios Conides . Dimitris Klaoudatos

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Abstract Allometric data of marine fish species from Rhodes, southeastern Aegean Sea are scarce. Their collection is crucial as they provide important information on the ongoing changes of small-scale fisheries in Rhodian coastal marine waters, a highly affected region of the Eastern Mediterranean by biological invasions. Monthly experimental trials and random samplings with static nets were conducted from April 2021 to March 2022 in the coastal marine waters of eastern Rhodes, Levantine Sea. Experimental boat seining was deployed in November 2022 in the coastal waters of northwest Rhodes, Aegean Sea. Total length and total weight of several individuals of 21 fish species were measured and the length-weight relationships of 12 indigenous and nine non-indigenous fish species were examined. The allometric coefficient (b) did not differ significantly from 3.00 for most of the species (70%), demonstrating isometric growth. Positive and negative allometry were found for three indigenous and three non-indigenous species. The largest and heaviest species were the bluespotted cornetfish (*Fistularia commersonii*), with a maximum TL of 117.60 cm and the silver-cheeked toadfish (*Lagocephlaus sceleratus*), with a maximum weight of 4640.90 g. Statistically significant positive allometric relationships were found for three non-indigenous fish, namely the bluespotted cornetfish, the devil firefish (*Pterois miles*) and the dusky spinefoot (*Siganus luridus*), suggesting that these species are thriving in the under-study area.

Keywords Levantine sea . Set nets . Static nets . Allometry . Coastal fisheries . Alien species . Invasive fish . Eastern Mediterranean

Introduction

Biological invasions are a phenomenon intensively observed in the Mediterranean Sea with emphasis in

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Gerasimos Kondylatos (✉)
Hydrobiological Station of Rhodes, Hellenic Centre for Marine Research, Rhodes, 85131, Greece and Department of Ichthyology and Aquatic Environment (DIAE), University of Thessaly (UTh), School of Agricultural Sciences, Volos, 38 446, Greece
e-mail: gkondylatos@hcmr.gr

Ilias Kallias
Institute of Marine Biological Resources and Inland Waters, Hellenic Center for Marine Research, Anavissos, 19013, Greece

Dimitris Vafidis . Athanasios Exadactylos . Alexandros Theocharis
Department of Ichthyology and Aquatic Environment (DIAE), School of Agricultural Sciences, University of Thessaly (UTh), Volos, 38446, Greece

Dimitris Mavrouleas . Konstantinos Kalaentzis. Maria Avgoustinaki
Hydrobiological Station of Rhodes, Hellenic Centre for Marine Research, Rhodes, 85131, Greece

Alexios Conides
Institute of Marine Biological Resources and Inland Waters, Hellenic Center for Marine Research, Anavissos, 19013, Greece

Dimitris Klaoudatos
Department of Ichthyology and Aquatic Environment (DIAE), School of Agricultural Sciences, University of Thessaly (UTh), Volos, 38446, Greece

its eastern parts, where the majority of the Indo-Pacific/Red Sea origin non-indigenous species (NIS) were introduced via the Suez Canal (Galil et al. 2018, 2021; Korakaki et al. 2021). The oligotrophic subtropical environment of the south Aegean Sea and Levantine is suitable for tropical or subtropical NIS colonization sometimes in the form of invasion and for indigenous thermophilic biota (Papaconstantinou 2014; Corsini-Foka et al. 2015). The ongoing warming of the Mediterranean Sea enhances the establishment and spreading of NIS in the under-study area (Raitsos et al. 2010; Pancucci-Papadopoulou et al. 2012; Sisma-Ventura et al. 2014). Inevitably, the Mediterranean biodiversity is under constant alteration (Bianchi et al. 2012; Zenetos et al. 2018; Michailidis et al. 2019; Ragkousis et al. 2023) with the synthesis of communities, habitats and ecosystem functioning and services heavily affected (Coll et al. 2010; Katsanevakis et al. 2018).

Length-weight relationship (LWR) is a crucial tool for understanding fish biology, physiology, ecology, stock assessment and population dynamics (Erzini 1994; Oscoz et al. 2005; Falsone et al. 2022). The proper management of any fish species requires the comprehension of LWR, commonly employed in the estimation of fish stocks and populations (King 2007) and typically calculated with the application of the power regression formula $W = aL^b$. The exponent 'b' (slope) values reveal important details of fish growth (Froese 1998; Can et al. 2002; Moutopoulos and Stergiou 2002). Fish may exhibit isometric growth, negative allometric growth, or positive allometric growth, according to Nehemia et al. (2012). When an organism grows isometrically, there is no change in the shape of the body. As the fish increases in length, positive allometric growth suggests that it becomes substantially stouter or deeper-bodied, whereas negative allometric growth suggests that it becomes thinner (Riedel et al. 2007).

Numerous studies have highlighted the significance in establishing LWR in fishes, providing details on their physical traits, growth pattern, general health, and habitat conditions (Schneider et al. 2000; Froese 2006). The LWR is an essential function in fisheries science that can be used to evaluate total catch, biomass, or length-frequency samples (Froese 2006). Furthermore, LWR are frequently used in fisheries biology to estimate weight at age from growth in length equations, in models for stock assessment (Pauly and Christensen 1993), assess condition indices (Anderson et al. 1983) and compare the morphological characteristics of populations from various geographic regions. Additionally, LWR information can be used to compare the life histories of various species across regions (Gonçalves et al. 1997; Moutopoulos and Stergiou 2002). Lastly, LWR can be used as an ecological indicator to evaluate the degree invasive species affect native species and their habitats (Fogg et al. 2019).

Throughout Greek seas, a plethora of studies has been conducted on the relationship between length and weight. Specifically, in the Aegean Sea (Moutopoulos and Stergiou 2002), North Aegean Sea (Koutrakis and Tsikliras 2003; Lamprakis et al. 2003; Karachle and Stergiou 2008; Adamidou et al. 2020), Argolikos Gulf (Kapiris and Klaoudatos 2011), South Euboikos Gulf (Petrakis and Stergiou 1995), North Ionian Sea (Evagelopoulos et al. 2020), Southern Ionian Sea (Dimitriadis and Fournari-Konstantinidou 2018) and Korinthiakos Gulf (Moutopoulos et al. 2013). According to Dimarchopoulou et al. (2017), LWR is the biological trait of marine fishes in the Mediterranean Sea that has received the most attention from the researchers. However, studies on LWR for NIS such as Lessepsian migrant fish species from the eastern Mediterranean coast are scarce (Bilecenoglu and Kaya 2002; Taskavak and Bilecenoglu 2001; Ergüden et al. 2009).

The aim of the present study was to provide crucial information of current populations through the LWR for both indigenous species (is) and NIS for the first time in the Greek waters and more specifically southeast of Rhodes Island (Eastern Mediterranean), a highly invaded region.

Materials and methods

Sampling was conducted through scheduled, monthly experimental fishing trials from April 2021 to March 2022 within the eastern coastal waters of Rhodes (Levantine), Greece. Gill net (GNS), trammel net (GTR), longline (LLS) and jig (LHP), as illustrated in Frid and Belmaker (2019), were set monthly. These are the most commonly fishing gear most commonly used by the small-scale fishers of Rhodes (Kondylatos et al. 2023a) (Fig. 1). Additional to the scheduled fishing trials, fish from random collections of individuals caught with the same fishing gear were assessed in the same fishing areas and period. For the purpose of the study, the only species collected with boat seining (SV) was the yellow-stripe barracuda (*Sphyraena chrysotaenia*) in November 2022 from the northwestern coastal waters of Rhodes (Aegean Sea). All fishing gear abbreviations follow He et al. (2021). The sex of all individuals collected in the present study was not determined. Total length (TL) and total weight (TW) were measured to the nearest 0.10 cm and 0.01 g, respectively. All fishing trials were conducted by local fishers who applied the exact same methodology they use when they practice their profession, thus no handling of live fish was conducted by any member of the scientific team and authors of the present study.

LWRs were estimated for the total population (combined sexes) of each species. Each LWR was calculated according to Quinn and Deriso (1999) by fitting a curvilinear power regression equation (1) to the data, where TW is expressed in grams (g) and TL in centimetres (cm), “a” is the intercept of the curve (growth factor), and ‘b’ the slope (allometry coefficient).

$$\mathrm{W} = \mathrm{a} \times \mathrm{TL}^{\mathrm{b}} \tag{1}$$

The slope values reveal details of fish growth. When referring to values that are b = 3.00, we used the term “isometric growth” after Ricker (1958) and for values exhibiting significant departure from b = 3.00, we used the term “allometric growth” after Bagenal and Tesch (1978). Values over three are referred as positive allometry and values lower than three as negative allometry.

Specific abiotic factors and/or fish condition may affect the value of the slope significantly differentiating its value from three (Ricker and Carter 1958). Possible outliers (data points whose response values did not follow the overall trend of the remaining data) were eliminated from the original dataset according to Evagelopoulos et al. (2017) and Froese et al. (2011). The standard Student t-test was employed to assess allometric relationships and compare the differences between the predicted LWRs values of the present study with those reported in the literature using Minitab 21 software (Minitab, Pennsylvania, PA, USA) at an alpha level of 0.05.

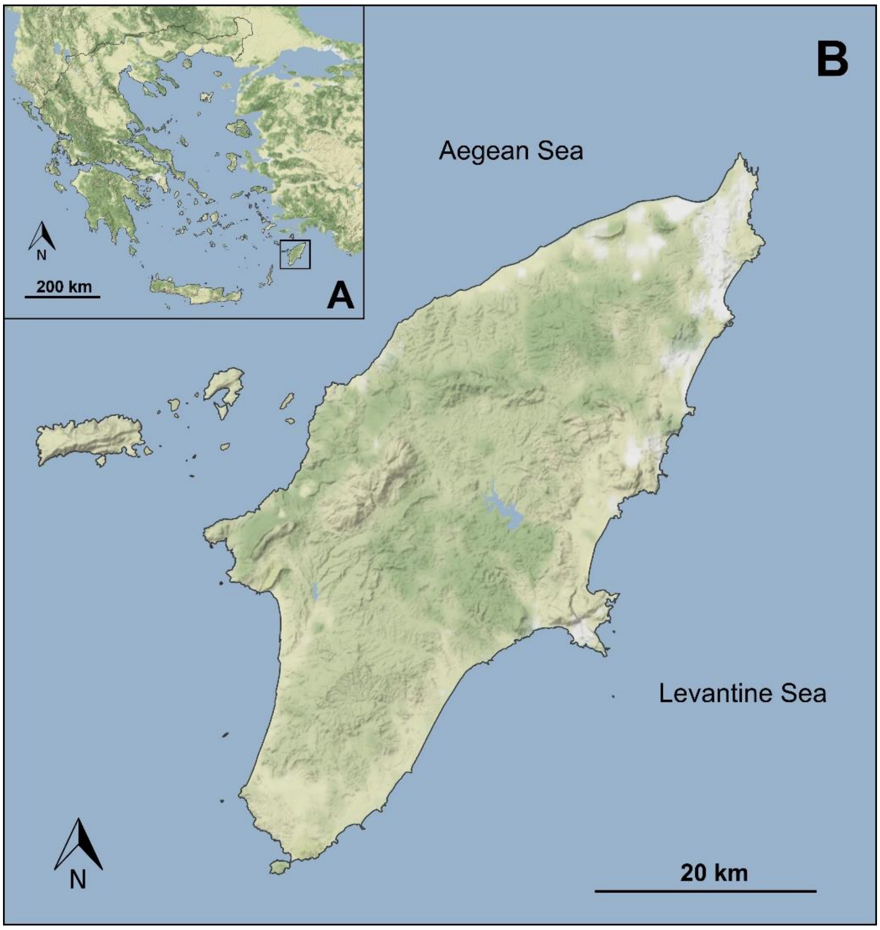

Fig. 1 Map of the study area. Map of Greece with the location of Rhodes denoted (A) and Rhodes (B)

Results

A total of 2673 individuals were caught with a total of 21 fish species, 12 (57.00%) of which were IS and 9 (43.00%) NIS. Sample size ranged from 52 individuals for the surmullet (*Mullus surmuletus*) to 721 individuals for the silver-cheeked toadfish (Table 1).

No lack of fit was detected for any of the models ($p>0.05$), with the smallest coefficient of determination (R^2) value estimated at 0.74 for the axillary seabream (*Pagellus acarne*). Slopes ranged from 2.20 for the axillary seabream to 3.50 for the bluespotted cornetfish. Except for the axillary seabream (‘b’ = 2.20) and the blotched picarel (*Spicara maena*) (‘b’ = 2.54), all remaining slopes were greater than 2.72, with an average of 3.02. The intercept (a) of LWR ranged between 0.00008 for the bluespotted cornetfish and 0.11914 for the axillary seabream (Table 2).

In total, 15 species (10 IS and five NIS) exhibited isometric growth, three negative allometric (two IS and one NIS) and three positive allometric (NIS) growth respectively (Table 2, Fig. 1). The largest and the heaviest species were the bluespotted cornetfish, with a maximum TL of 117.60 cm and the silver-cheeked

Table 1 Origin, number of individuals and descriptive statistics of 21 species collected from the coastal waters of Rhodes, Greece

Species	Origin	n	MTL±SD (cm)	MW±SD (g)	TL Range (cm)	TW Range (g)
Boops boops	IS	101	17.59±5.91	77.25±54.53	5.80-26.30	1.38-214.20
Bothus podas	IS	56	14.54±1.84	37.37±15.24	11.00-20.20	12.92-160.00
Diplodus vulgaris	IS	61	18.31±1.37	105.01±27.01	13.90-20.50	56.50-167.50
Mullus surmuletus	IS	52	20.86±2.89	127.24±62.89	14.70-30.30	40.00-421.30
Pagellus acarne	IS	58	16.49±1.04	57.09±9.32	14.70-19.30	29.00-82.10
Pagellus erythrinus	IS	69	17.83±3.60	81.82±51.58	6.00-28.00	7.60-294.00
Pagrus pagrus	IS	56	16.89±3.19	87.20±53.70	10.80-23.20	20.00-232.20
Scorpaena scrofa	IS	58	19.89±3.18	142.60±79.10	15.90-29.60	59.00-380.00
Sparisoma cretense	IS	239	21.56±3.88	170.69±91.45	9.00-263.00	12.00-510.00
Spicara maena	IS	103	17.44±2.65	77.52±33.78	9.30-23.10	8.80-160.00
Spicara smaris	IS	59	13.08±4.84	34.76±26.26	4.40-17.80	0.62-67.80
Synodus saurus	IS	56	25.16±5.00	137.01±70.70	14.20-33.60	16.00-300.00
Fistularia commersonii	NIS	204	75.55±14.88	317.00±207.80	40.20-117.60	29.30-1353.80
Lagocephalus sceleratus	NIS	721	33.59±15.63	730.10±869.10	8.50-73.50	7.00-4640.9
Parupeneus forsskali	NIS	55	21.25±2.43	121.85±39.45	14.30-25.90	34.00-226.7
Pempheris rhomboidea	NIS	56	15.24±1.57	53.89±15.52	11.60-17.60	25.00-81.00
Pterois miles	NIS	355	26.22±3.97	258.86±132.35	15.70-37.80	40.71-787.80
Sargocentron rubrum	NIS	60	17.19±1.72	103.53±26.68	11.10-19.30	26.70-145.00
Siganus luridus	NIS	58	16.07±4.28	82.36±52.37	5.90-23.00	2.94-267.00
Siganus rivulatus	NIS	108	19.57±3.39	111.20±45.14	5.90-24.40	2.00-191.00
Sphyraena chrysotaenia	NIS	88	77.06±33.38	23.47±3.17	17.80-29.90	28.30-148.65

Abbreviations: IS = indigenous species, NIS = non-indigenous species, n = number of individuals measured, MW = mean weight (in g), MTL = mean total length (in cm), SD = standard deviation, TL = total length, TW = total weight

Table 2 Length vs weight allometric relationship, significance and coefficient of determination of 21 fish species (combined sexes) collected from the coastal waters of Rhodes, Greece

Species	a	b	R^2	Allometry	t-test	Relationship
Boops boops	0.01601	2.8599	0.92	-ve	Ns	$TW = 0.016006 \times TL^{2.85990}$
Bothus podas	0.01294	2.9611	0.96	-ve	Ns	$TW = 0.01294 \times TL^{2.96108}$
Diplodus vulgaris	0.00421	3.4746	0.86	+ve	Ns	$TW =0.0042082 \times TL^{3.47455}$
Fistularia commersonii	0.00008	3.4897	0.97	+ve	***	$TW = 0.000075 \times TL^{3.48965}$
Lagocephalus sceleratus	0.01580	2.9152	0.97	-ve	**	$TW = 0.015798 \times TL^{2.91516}$
Mullus surmuletus	0.00798	3.1621	0.91	+ve	Ns	$TW = 0.007977 \times TL^{3.16209}$
Pagellus acarne	0.11914	2.2002	0.74	-ve	***	$TW = 0.119135 \times TL^{2.20021}$
Pagellus erythrinus	0.01060	3.0630	0.96	+ve	Ns	$TW = 0.010595 \times TL^{3.06301}$
Pagrus pagrus	0.00624	3.3316	0.94	+ve	Ns	$TW = 0.006240 \times TL^{3.33156}$
Parupeneus forsskali	0.01266	2.9885	0.92	-ve	Ns	$TW = 0.012663 \times TL^{2.98859}$
Pempheris rhomboidea	0.02068	2.8775	0.94	-ve	Ns	$TW = 0.0206797 \times TL^{2.87754}$
Pterois miles	0.00639	3.2269	0.94	+ve	***	$TW = 0.006391 \times TL^{3.22686}$
Sargocentron rubrum	0.02378	2.9370	0.91	-ve	Ns	$TW= 0.0237828 \times TL^{2.93701}$
Scorpaena scrofa	0.03997	2.7176	0.91	-ve	Ns	$TW = 0.039971 \times TL^{2.71761}$
Siganus luridus	0.00605	3.3459	0.94	+ve	*	$TW = 0.006057 \times TL^{3.34597}$
Siganus rivulatus	0.00997	3.1058	0.90	+ve	Ns	$TW = 0.009979 \times TL^{3.10588}$
Sparisoma cretense	0.01190	3.0845	0.94	+ve	Ns	$TW = 0.011898 \times TL^{3.08450}$
Spicara maena	0.05191	2.5430	0.75	-ve	**	$TW = 0.051908 \times TL^{2.54300}$
Spicara smaris	0.00903	3.0849	0.98	+ve	Ns	$TW = 0.009032 \times TL^{3.08487}$
Synodus saurus	0.00744	3.0133	0.95	+ve	Ns	$TW = 0.007447 \times TL^{3.01335}$
Sphyraena chrysotaenia	0.00478	3.0528	0.97	+ve	Ns	$TW = 0.004777 \times TL^{3.05284}$

Abbreviations: a = intercept, ‘b’ = slope, R^2= coefficient of determination, -ve = negative, +ve = positive, Ns = non-significant, * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$

toadfish, with a weight of 4640.90 g.

The majority of IS and NIS species exhibited isometric LWR (83.30% and 62.50% respectively) with only the NIS exhibiting positive allometry (37.50%) (Fig. 2). The LWR for each species estimated in the present study along with those found in the literature are summarized in Table 3.

Discussion

LWRs differ among fish species depending on biotic factors such as the inherited body shape and the physiological state of the species, in terms of maturity (gonads stages), spawning, the fullness of stomach and general condition of appetite (Schneider et al. 2000; Flura et al. 2015) and abiotic factors such as the season or even days (De Giosa et al. 2014). Growth can also differ in the same species dwelling in different locations, influenced by numerous biotic and abiotic factors either natural or human-related, including sex, habitat, health status and diet, the geographical pattern (e.g., longitude, latitude, and altitude), climate, temperature, salinity and anthropogenic activities such as habitat change or degredation, pollution and fishing pressure (Bagenal and Tesch 1978; Moutopoulos and Stergiou 2002; Giacalone et al. 2010; Gurkan and Taskavak 2007; Vieira et al. 2014; Balasubramanian and Murugan 2017; Kelly et al. 2017).

The present study supplements the current body of literature and aids fish biologists and management experts alike estimate weights for fish that have been measured but not weighed, since weight is a good predictor of fish health (Le Cren 1951; Vazzoler and Amato 1996). The length-weight correlation presented herein may be valuable in ongoing research of commercial fish landings as well as a future benchmark for comparisons of parameters assessed comparably in other Mediterranean regions. Most published research apply LWRs comparisons by "visual inspection", without employing a statistical technique, which sometimes renders the results unsuitable for identifying differences (Falsone et al. 2022). Therefore, to objectively discover variations in slopes and intercepts amongst LWRs, the methodology used in this work may be preferable.

Surprisingly, only NIS species exhibited positive allometric relationships, suggesting that their growth

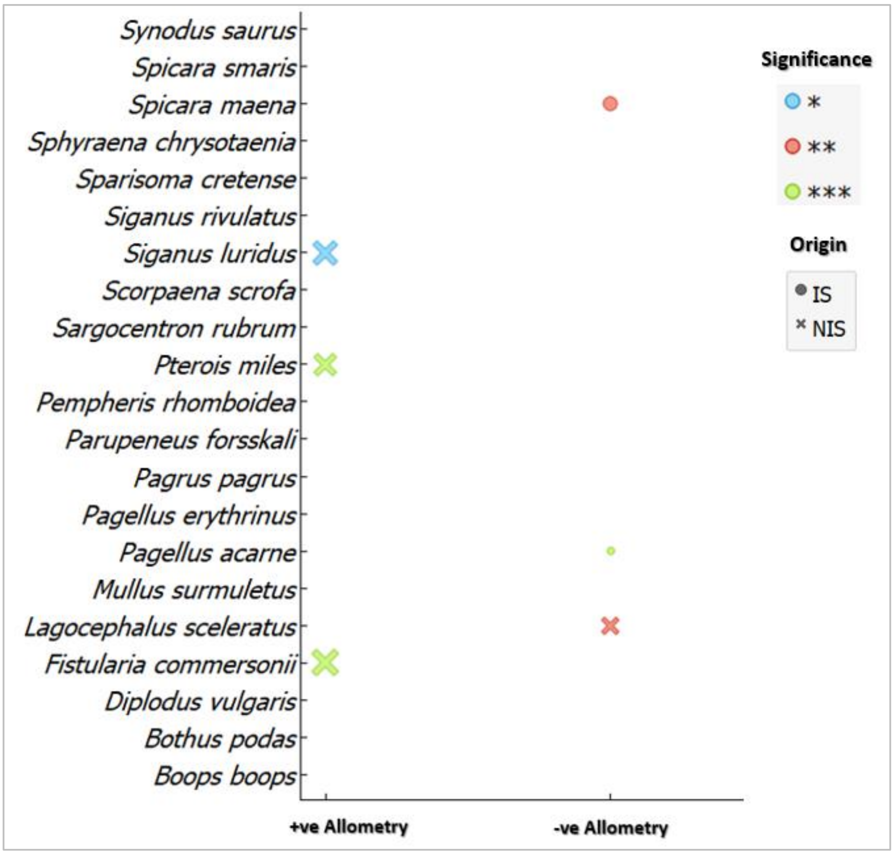

Fig. 2 Scatter plot of species origin, and significance of each allometric LWR (size indicates the slope magnitude)

Table 3 Published LWRs of 21 fish species from the Mediterranean Sea and the Gulf of Suez

Species	Origin	a	'b'	Location	Fishing gear	Depth (m)	Reference
Boops boops	IS	0.016	2.859	Rhodes (Greece)	GNS, GTR	8–35	Present study
B. boops	IS	0.013 ^{ns}	2.882 ^{ns}	Gulf of Antalya (Turkey)	OTB, TM	U	(Koca 2023)
B. boops	IS	0.0119 ^{ns}	2.9453 ^{ns}	Alexandria (Egypt)	GNS	0–20	(Ragheb 2023)
B. boops	IS	0.006 ^{ns}	3.171*	South of Sicily (Italy)	OTB	<100 – >200	(Falsone et al. 2022)
B. boops	IS	0.012 ^{ns}	2.945 ^{ns}	Alexandria (Egypt)	GNS	0–1	(El Samman et al. 2022)
B. boops	IS	0.004 ^{ns}	3.270**	Egypt	OTB	U	(Mehanna and Farouk 2021)
B. boops	IS	0.0025 ^{ns}	3.47***	Northern Aegean Sea (Greece)	GNS, GTR	0-60	(Adamidou et al. 2020)
B. boops	IS	0.005 ^{ns}	3.192*	Oran Bay (Algeria)	OTB	132–350	(Talet et al. 2017)
B. boops	IS	0.00006*	2.610 ^{ns}	Argolikos Gulf (Greece)	GNS, GTR	U	(Kapiris and Klaoudatos 2011)
B. boops	IS	0.0085 ^{ns}	3.092 ^{ns}	Gökova Bay (Turkey)	GTR, LLS	U	(Ceyhan et al. 2009)
B. boops	IS	0.004 ^{ns}	3.13 ^{ns}	Gulf of Tunis	OTB	40–100	(Chérif et al. 2008)
B. boops	IS	0.007 ^{ns}	3.140 ^{ns}	Central Aegean Sea (Greece)	OTB	30–70	(İlkyaz et al. 2008)
B. boops	IS	0.008 ^{ns}	3.049 ^{ns}	Babadillimani Bight (Turkey)	OTB	20–100	(Cicek et al. 2006)
B. boops	IS	0.0127 ^{ns}	3.033 ^{ns}	Izmir Bay (Turkey)	GNS, GTR, OTB, SB	U	(Özaydin and Taskavak 2006)
B. boops	IS	0.012 ^{ns}	2.855 ^{ns}	Balearic Isl. and eastern IP (Spain)	GTR, LLS	8–35	(Morey et al. 2003)
B. boops	IS	0.000012*	3.093 ^{ns}	South Euboikos Gulf (Greece)	GNS, GTR, SB	U	(Petrakis and Stergiou 1995)
Bothus podas	IS	0.013	2.961	Rhodes (Greece)	GNS, GTR	8–35	Present study
B. podas	IS	0.016 ^{ns}	2.901 ^{ns}	Egypt	OTB	U	(Mehanna and Farouk 2021)
B. podas	IS	0.011 ^{ns}	3.034 ^{ns}	Thermaikos Gulf and North-Northwest Aegean Sea (Greece)	GNS, OTB, PS	U	(Karachle and Stergiou 2008)
B. podas	IS	0.004***	3.394 ^{ns}	Izmir (Turkey)	OTB	U	(Özaydın et al. 2007)
B. podas	IS	0.009 ^{ns}	3.099 ^{ns}	Babadillimani Bight (Turkey)	OTB	20–100	(Cicek et al. 2006)
B. podas	IS	0.009 ^{ns}	3.079 ^{ns}	Balearic Isl and eastern IP (Spain)	GTR, LLS	8–35	(Morey et al. 2003)
B. podas	IS	0.017 ^{ns}	2.801 ^{ns}	Naxos, Aegean Sea (Greece)	GNS, LLS	U	(Moutopoulos and Stergiou 2002)
Diplodus vulgaris	IS	0.004	3.475	Rhodes (Greece)	GNS, GTR	8–35	Present study
D. vulgaris	IS	0.019***	2.906 ^{ns}	Alexandria (Egypt)	GNS	0–20	(Ragheb 2023)
D. vulgaris	IS	0.023***	2.914 ^{ns}	Egypt	OTB	U	(Mehanna and Farouk 2021)
D. vulgaris	IS	0.0114***	3.090 ^{ns}	Northern Aegean Sea (Greece)	GNS, GTR	0-60	(Adamidou et al. 2020)
D. vulgaris	IS	0.0123***	3.070 ^{ns}	Korinthiakos Gulf (Greece)	GNS, GTR	50-300	(Moutopoulos et al. 2013)
D.vulgaris	IS	0.0145*	3.034 ^{ns}	Gökova Bay (Turkey)	GTR, LLS	U	(Ceyhan et al. 2009)
D. vulgaris	IS	0.005 ^{ns}	3.460 ^{ns}	Central Aegean Sea (Greece)	OTB	30–70	(İlkyaz et al. 2008)
D. vulgaris	IS	0.019***	2.91*	North Aegean Sea (Turkey)	GTR	0–40	(Gökçe et al. 2007)
D. vulgaris	IS	0.086***	2.431**	Gokceada Island (Turkey)	GNS, GTR	< 30	(Karakulak et al. 2006)
D. vulgaris	IS	0.0184**	3.094 ^{ns}	Izmir Bay (Turkey)	GNS, GTR, OTB, SB	U	(Özaydin and Taskavak 2006)
D. vulgaris	IS	0.015**	3.006 ^{ns}	Balearic Isl. and eastern IP (Spain)	GTR, LLS	8–35	(Morey et al. 2003)
D. vulgaris	IS	0.000098 ^{ns}	2.710*	South Euboikos Gulf (Greece)	GNS, GTR, SB	U	(Petrakis and Stergiou 1995)
Fistularia commersonii	NIS	0.0001	3.4897	Rhodes (Greece)	GNS, GTR	8–35	Present study
F. commersonii	NIS	0.0038***	2.935***	Egypt	OTB	U	(Mehanna and Farouk 2021)
F. commersonii	NIS	0.0001***	3.619**	South of Sicily (Italy)	OTB, U	U	(Vitale et al. 2016)

Table 3 Continued

F. commersonii	NIS	0.0118***	2.727***	Southern Aegean Sea (Turkey)	OTB	30–225	(Bilge et al. 2014)
F. commersonii	NIS	0.0001 ^{ns}	3.406 ^{ns}	Lebanon	GTR, SB	U	(Bariche and Kajajian 2012)
F. commersonii	NIS	0.0112***	2.504***	Iskenderun Bay (Turkey)	OTB	12–120	(Ergüden et al. 2009)
Lagocephalus sceleratus	NIS	0.016	2.915	Rhodes (Greece)	GNS, GTR, LHP, LLS	8–35	Present study
L. sceleratus	NIS	0.012 ^{ns}	3.020**	Mersin Bay (Turkey)	GTR	U	(Torcu-Koç et al. 2020)
L. sceleratus	NIS	0.016 ^{ns}	2.927 ^{ns}	Muğla (Turkey)	GTR, LLS, OTB	U	(Bilge et al. 2017)
L. sceleratus	NIS	0.012 ^{ns}	2.981*	Gulf of Antalya (Turkey)	GNS, GTR, LLS, OTB	U	(Aydin et al. 2017)
L. sceleratus	NIS	0.143***	2.990**	Lebanon	U	U	(Boustany et al. 2015)
L. sceleratus	NIS	0.029*	2.711***	Iskenderun Bay (Turkey)	GNS, PS	24–50, 8–20	(Başusta et al. 2013)
L. sceleratus	NIS	0.012 ^{ns}	2.980*	Gulf of Antalya (Turkey)	LLS, U	U	(Aydin 2011)
Mullus surmuletus	IS	0.008	3.162	Rhodes (Greece)	GNS	8–35	Present study
M. surmuletus	IS	0.013 ^{ns}	2.920 ^{ns}	Marmara Sea (Turkey)	GNS, GTR, LLS	15–195	(Karadurmuş 2022)
M. surmuletus	IS	0.013 ^{ns}	2.971 ^{ns}	South of Sicily (Italy)	OTB	<100 – >200	(Falsone et al. 2022)
M. surmuletus	IS	0.010 ^{ns}	3.062 ^{ns}	Egypt	OTB	U	(Mehanna and Farouk 2021)
M. surmuletus	IS	0.011 ^{ns}	2.970 ^{ns}	Oran Bay (Algeria)	OTB	130–350	(Talet et al. 2017)
M. surmuletus	IS	0.009 ^{ns}	3.099 ^{ns}	Mediterranean coast (Egypt)	OTB	< 100	(Akel 2016)
M. surmuletus	IS	0.0037 ^{ns}	3.381 ^{ns}	Korinthiakos Gulf (Greece)	GNS, GTR	50-300	(Moutopoulos et al. 2013)
M. surmuletus	IS	0.0069 ^{ns}	3.214 ^{ns}	Gökova Bay (Turkey)	GTR, LLS	U	(Ceyhan et al. 2009)
M. surmuletus	IS	0.006 ^{ns}	3.270 ^{ns}	Central Aegean Sea (Greece)	OTB	30–70	(İlkyaz et al. 2008)
M. surmuletus	IS	0.003 ^{ns}	3.492*	Thermaikos Gulf and North-Northwest Aegean Sea (Greece)	GNS, OTB, PS	U	(Karachle and Stergiou 2008)
M. surmuletus	IS	0.008 ^{ns}	3.110 ^{ns}	Babadillimani Bight (Turkey)	OTB	20–100	(Cicek et al. 2006)
M. surmuletus	IS	0.0167*	3.011 ^{ns}	Izmir Bay (Turkey)	GNS, GTR, OTB, SB	U	(Özaydin and Taskavak 2006)
M. surmuletus	IS	0.007 ^{ns}	3.169 ^{ns}	Balearic Isl. and eastern IP (Spain)	GTR, LLS	8–35	(Morey et al. 2003)
M. surmuletus	IS	0.000009*	3.140 ^{ns}	South Euboikos Gulf (Greece)	GNS, GTR, SB	U	(Petrakis and Stergiou 1995)
Pagellus acarne	IS	0.119	2.200	Rhodes (Greece)	GNS, GTR	8–35	Present study
P. acarne	IS	0.0113 ^{ns}	3.0283***	Alexandria (Egypt)	GNS	0–20	(Ragheb 2023)
P. acarne	IS	0.009 ^{ns}	3.109***	South of Sicily (Italy)	OTB	<100 – >200	(Falsone et al. 2022)
P. acarne	IS	0.001 ^{ns}	3.054***	Saros Bay (Turkey)	OTB	20–500	(Gül et al. 2021)
P. acarne	IS	0.007 ^{ns}	3.221***	Egypt	OTB	U	(Mehanna and Farouk 2021)
P. acarne	IS	0.006 ^{ns}	3.280***	Northern Aegean Sea (Greece)	GNS, GTR	0-60	(Adamidou et al. 2020)
P. acarne	IS	0.003 ^{ns}	3.521***	Strait of Sicily (Italy)	OTB	85 (MD)	(Di Maio et al. 2020)
P. acarne	IS	0.009 ^{ns}	3.100***	Oran Bay (Algeria)	OTB	131–350	(Talet et al. 2017)
P. acarne	IS	0.00002	2.88**	Argolikos Gulf (Greece)	GTR, SV	U	(Kapiris and Klaoudatos 2011)
P. acarne	IS	0.0094 ^{ns}	3.265***	Gökova Bay (Turkey)	GTR, LLS	U	(Ceyhan et al. 2009)
P. acarne	IS	0.008 ^{ns}	3.160***	Central Aegean Sea (Greece)	OTB	30–70	(İlkyaz et al. 2008)
P. acarne	IS	0.008 ^{ns}	3.146***	Babadillimani Bight (Turkey)	OTB	20–100	(Cicek et al. 2006)
P. acarne	IS	0.0064 ^{ns}	3.383***	Izmir Bay (Turkey)	GNS, GTR, OTB, SB	U	(Özaydin and Taskavak 2006)
P. acarne	IS	0.007 ^{ns}	3.208***	Balearic Isl. and eastern IP (Spain)	GTR, LLS	8–35	(Morey et al. 2003)
P. acarne	IS	0.000005 ^{ns}	3.272***	South Euboikos Gulf (Greece)	GNS, GTR, SB	U	(Petrakis and Stergiou 1995)
Pagellus erythrinus	IS	0.011	3.063	Rhodes (Greece)	GNS, GTR	8–35	Present study
P. erythrinus	IS	0.0172*	2.8545**	Alexandria (Egypt)	GNS	0–20	(Ragheb 2023)
P. erythrinus	IS	0.019**	2.879*	South of Sicily (Italy)	OTB	<100 – >200	(Falsone et al. 2022)

Table 3 Continued

P. erythrinus	IS	0.009 ^{ns}	3.118 ^{ns}	Egypt	OTB	U	(Mehanna and Farouk 2021)
P. erythrinus	IS	0.0177*	2.863**	Korinthiakos Gulf (Greece)	GNS, GTR	50-300	(Moutopoulos et al. 2013)
P. erythrinus	IS	0.00002***	2.860**	Argolikos Gulf (Greece)	GTR, LLS	U	(Kapiris and Klaoudatos 2011)
P. erythrinus	IS	0.011 ^{ns}	3.030 ^{ns}	Gulf of Gabes (Tunisia)	GNS, GTR, OTB, SV	U	(Ghailen et al. 2010)
P. erythrinus	IS	0.0178*	2.855**	Gökova Bay (Turkey)	GTR, LLS	U	(Ceyhan et al. 2009)
P. erythrinus	IS	0.017*	2.850**	Gulf of Tunis (Tunisia)	OTB	40–100	(Chérif et al. 2008)
P. erythrinus	IS	0.019**	2.860**	Central Aegean Sea (Greece)	OTB	30–70	(İlkyaz et al. 2008)
P. erythrinus	IS	0.0144 ^{ns}	2.966 ^{ns}	Thermaikos Gulf and North-Northwest Aegean Sea (Greece)	GNS, OTB, PS	U	(Karachle and Stergiou 2008)
P. erythrinus	IS	0.015 ^{ns}	2.840**	Babadillimani Bight (Turkey)	OTB	20–100	(Cicek et al. 2006)
P. erythrinus	IS	0.0193**	2.979 ^{ns}	Izmir Bay (Turkey)	GNS, GTR, OTB, SB	U	(Özaydin and Taskavak 2006)
P. erythrinus	IS	0.016*	2.894*	Balearic Isl. and eastern IP (Spain)	GTR, LLS	8–35	(Morey et al. 2003)
P. erythrinus	IS	0.000017***	3.028 ^{ns}	South Euboikos Gulf (Greece)	GNS, GTR, SB	U	(Petrakis and Stergiou 1995)
Pagrus pagrus	IS	0.00624	3.3316	Rhodes (Greece)	GNS, GTR	8–35	Present study
P.pagrus	IS	0.026**	2.833 ^{ns}	South of Sicily (Italy)	OTB	<100 – >200	(Falsone et al. 2022)
P. pagrus	IS	0.018*	2.950 ^{ns}	Egypt	OTB	U	(Mehanna and Farouk 2021)
P. pagrus	IS	0.016 ^{ns}	2.965 ^{ns}	Gokceada Island (Turkey)	LLS	0–120	(Ayyildiz et al. 2020)
P.pagrus	IS	0.027***	2.827 ^{ns}	Gallipoli peninsula (Turkey)	LLS	0–400	(Öztekin et al. 2016)
P.pagrus	IS	0.018*	2.946 ^{ns}	Korinthiakos Gulf (Greece)	GNS, GTR	50-300	(Moutopoulos et al. 2013)
P. pagrus	IS	0.017*	2.970 ^{ns}	Central Aegean Sea (Greece)	OTB	30–70	(İlkyaz et al. 2008)
P. pagrus	IS	0.028***	2.800*	Balearic Isl. and eastern IP (Spain)	GTR, LLS	8–35	(Morey et al. 2003)
P. pagrus	IS	0.0152 ^{ns}	3.005 ^{ns}	Naxos, Aegean Sea (Greece)	GNS, LLS	U	(Moutopoulos and Stergiou 2002)
Parupeneus forsskali	NIS	0.013	2.989	Rhodes (Greece)	GNS, GTR	8–35	Present study
P. forsskali	NIS	0.010 ^{ns}	3.030 ^{ns}	Aegean Sea (Greece)	GNS, GTR, U	20–30	(Vagenas et al. 2023)
P. forsskali	NIS	0.002 ^{ns}	3.534 ^{ns}	Iskenderun Bay (Turkey)	GTR	20–30	(Turan et al. 2021)
P. forsskali	NIS	0.021 ^{ns}	2.800**	Red Sea (Egypt)	GNS, GTR, LLS	1–10	(Sabrah 2015)
Pempheris rhomboidea	NIS	0.021	2.878	Rhodes (Greece)	GNS, GTR	8–35	Present study
P. rhomboidea	NIS	0.012 ^{ns}	3.165 ^{ns}	Gulf of Antalya (Turkey)	GTR	U	(Türker et al. 2020)
P. rhomboidea	NIS	0.00001*	3.026 ^{ns}	Eastern Mediterranean (Turkey)	OTB	10–80	(Taskavak and Bilecenoglu 2001)
Pterois miles	NIS	0.006	3.227	Rhodes (Greece)	GNS, GTR	8–35	Present study
P. miles	NIS	0.008*	3.171 ^{ns}	Iskenderun Bay (Turkey)	U	U	(Dağhan and Demirhan 2020)
P. miles	NIS	0.00854 ^{ns}	3.154 ^{ns}	Cyprus	Hawaiian slings, U	0–30	(Savva et al. 2020)
Sargocentron rubrum	NIS	0.02378	2.9370	Rhodes (Greece)	GNS, GTR	8–35	Present study
S. rubrum	NIS	0.0376 ^{ns}	2.7248 ^{ns}	Egyptian Mediterranean waters	GNS	0-20	(Ragheb 2023)
S. rubrum	NIS	0.0138 ^{ns}	3.0915 ^{ns}	Cyprus	GTR	0–50	(Özvarol and Tatlises 2017)
S. rubrum	NIS	0.00001*	3.015 ^{ns}	Eastern Mediterranean (Turkey)	OTB	10–80	(Taskavak and Bilecenoglu 2001)
Scorpaena scrofa	IS	0.039	2.718	Rhodes (Greece)	GNS, GTR	8–35	Present study
S. scrofa	IS	0.018 ^{ns}	3.004 ^{ns}	İzmir Bay (Turkey)	U	U	(Bayhan et al. 2022)
S. scrofa	IS	0.024 ^{ns}	2.915 ^{ns}	Corfu, North Ionian Sea (Greece)	GNS, GTR, LLS	7-70	(Evagelopoulos et al. 2020)
S. scrofa	IS	0.016 ^{ns}	2.993 ^{ns}	İzmir Bay (Turkey)	LHM or LHP	U	(Arslan and Bostanci 2019)
S. scrofa	IS	0.0169 ^{ns}	3.002 ^{ns}	Korinthiakos Gulf (Greece)	GNS, GTR	50-300	(Moutopoulos et al. 2013)
S. scrofa	IS	0.026 ^{ns}	2.890 ^{ns}	Catalan Sea (France)	U	1-80	(Crec'hriou et al. 2012, 2013)

Table 3 Continued

S. scrofa	IS	0.0291 ^{ns}	2.796 ^{ns}	Izmir Bay (Turkey)	GNS, GTR, OTB, SB	U	(Özaydin and Taskavak 2006)
Siganus luridus	NIS	0.00605	3.3459	Rhodes (Greece)	GNS, GTR, SV	8–35	Present study
S. luridus	NIS	0.0166***	3.008*	Gulf of Antalya (Turkey)	GTR	U	(Türker et al. 2020)
S. luridus	NIS	0.0169***	2.96**	Gulf of Antalya (Turkey)	GTR	<10	(Begburs and Kebapcioglu 2013)
S. luridus	NIS	0.0172***	2.983**	Gökova Bay (Turkey)	GTR, LLS	U	(Ceyhan et al. 2009)
S. luridus	NIS	0.0136**	2.920**	Iskenderun Bay (Turkey)	OTB	13–120	(Ergüden et al. 2009)
Siganus rivulatus	NIS	0.0099	3.1058	Rhodes (Greece)	GNS, GTR, SV	8–35	Present study
S. rivulatus	NIS	0.0098 ^{ns}	3.0791 ^{ns}	Alexandria (Egypt)	GNS	0–20	(Ragheb 2023)
S. rivulatus	NIS	0.0112 ^{ns}	2.984 ^{ns}	Egypt	OTB	U	(Mehanna and Farouk 2021)
S. rivulatus	NIS	0.009 ^{ns}	3.097 ^{ns}	Gulf of Antalya (Turkey)	GTR	U	(Türker et al. 2020)
S. rivulatus	NIS	0.016 ^{ns}	2.880 ^{ns}	Gulf of Antalya (Turkey)	GTR	<10	(Begburs and Kebapcioglu 2013)
S. rivulatus	NIS	0.0170 ^{ns}	2.823 ^{ns}	Iskenderun Bay (Turkey)	OTB	14–120	(Ergüden et al. 2009)
S. rivulatus	NIS	0.009 ^{ns}	3.112 ^{ns}	Gökova Bay (Turkey)	GTR, LLS	U	(Ceyhan et al. 2009)
S. rivulatus	NIS	0.007137 ^{ns}	3.179 ^{ns}	Gulf of Antalya (Turkey)	GNS, LHP, U	2-40	(Bilecenoglu and Kaya 2002)
Sphyraena chrysotaenia	NIS	0.005	3.053	Rhodes (Greece)	SV	8–35	Present study
S. chrysotaenia	NIS	0.009***	3.079 ^{ns}	Egypt	GNS	0-20	(Ragheb 2023)
S. chrysotaenia	NIS	0.0102***	2.834**	Iskenderun Bay (Turkey)	GNS, OTB	12–44	(Ergüden and Ozdemir 2022)
S. chrysotaenia	NIS	0.012***	2.731***	Gulf of Suez (Egypt)	OTB, U	U	(ElGanainy et al. 2017)
S. chrysotaenia	NIS	0.0062 ^{ns}	3.038 ^{ns}	Gökova Bay (Turkey)	GTR, LLS	U	(Ceyhan et al. 2009)
S. chrysotaenia	NIS	0.005 ^{ns}	3.069 ^{ns}	Gulf of Gabes (Tunisia)	OTB	U	(Rim et al. 2007)
Sparisoma cretense	IS	0.012	3.0845	Rhodes (Greece)	GNS, GTR	8–35	Present study
S. cretense	IS	0.023***	2.837***	Gulf of Tunis (Tunisia)	GNS, GTR, OTB	U	(Miled-Fathalli et al. 2019)
S. cretense	IS	0.012 ^{ns}	3.117 ^{ns}	Southern Ionian Sea (Greece)	GTR, LLS	U	(Dimitriadis and Fournari-Konstantinidou, 2018)
S. cretense	IS	0.00568**	3.311***	Naxos, Aegean Sea (Greece)	GNS, LLS	U	(Moutopoulos and Stergiou 2002)
Spicara maena	IS	0.052	2.5430	Rhodes (Greece)	GNS, GTR	8–35	Present study
S. maena	IS	0.013 ^{ns}	2.988**	Egypt	OTB	U	(Mehanna and Farouk 2021)
S. maena	IS	0.016 ^{ns}	2.740 ^{ns}	Northern Aegean Sea (Greece)	GNS, GTR	0-60	(Adamidou et al. 2020)
S. maena	IS	0.031 ^{ns}	2.696 ^{ns}	Corfu, North Ionian Sea (Greece)	GNS, GTR, LLS	7-70	(Evagelopoulos et al. 2020)
S. maena	IS	0.005 ^{ns}	3.281***	Gulf of Tunis (Tunisia)	GNS, GTR, OTB	U	(Miled-Fathalli et al. 2019)
S. maena	IS	0.016 ^{ns}	2.923*	Southern Ionian Sea (Greece)	GTR, LLS	U	(Dimitriadis and Fournari-Konstantinidou 2018)
S. maena	IS	0.017 ^{ns}	2.85 ^{ns}	Gulf of Tunis (Tunisia)	OTB	40–100	(Chérif et al. 2008)
S. maena	IS	0.012 ^{ns}	2.980**	Central Aegean Sea (Greece)	OTB	30–70	(İlkyaz et al. 2008)
S. maena	IS	0.0068 ^{ns}	3.180***	Thermaikos Gulf and North-Northwest Aegean Sea (Greece)	GNS, OTB, PS	U	(Karachle and Stergiou 2008)
S. maena	IS	0.008 ^{ns}	3.115**	Babadillimani Bight (Turkey)	OTB	20–100	(Cicek et al. 2006)
S. maena	IS	0.0251 ^{ns}	2.767 ^{ns}	Izmir Bay (Turkey)	GNS, GTR, OTB, SB	U	(Özaydin and Taskavak 2006)
S. maena	IS	0.011 ^{ns}	2.869*	Balearic Isl. and eastern IP (Spain)	GTR, LLS	8–35	(Morey et al. 2003)
S. maena	IS	0.0104 ^{ns}	3.096**	Naxos, Aegean Sea (Greece)	GNS, LLS	U	(Moutopoulos and Stergiou 2002)
S. maena	IS	0.000083*	2.663 ^{ns}	South Euboikos Gulf (Greece)	GNS, GTR, SB	U	(Petrakis and Stergiou 1995)
Spicara smaris	IS	0.009	3.085	Rhodes (Greece)	GNS, SV	8–35	Present study

Table 3 Continued

S. smaris	IS	0.008 ^{ns}	3.069 ^{ns}	Egypt	OTB	U	(Mehanna and Farouk 2021)
S. smaris	IS	0.031**	2.599 ^{ns}	Gulf of Tunis (Tunisia)	GNS, GTR, OTB	U	(Miled-Fathalli et al. 2019)
S. smaris	IS	0.008 ^{ns}	3.070 ^{ns}	Central Aegean Sea (Greece)	OTB	30–70	(İlkyaz et al. 2008)
S. smaris	IS	0.019 ^{ns}	2.667 ^{ns}	Babadillimani Bight (Turkey)	OTB	20–100	(Cicek et al. 2006)
S. smaris	IS	0.0154 ^{ns}	2.935 ^{ns}	Izmir Bay (Turkey)	GNS, GTR, OTB, SB	U	(Özaydin and Taskavak 2006)
S. smaris	IS	0.011 ^{ns}	3.065 ^{ns}	Balearic Isl. and eastern IP (Spain)	GTR, LLS	8–35	(Morey et al. 2003)
S. smaris	IS	0.000013 ^{ns}	2.987 ^{ns}	South Euboikos Gulf (Greece)	GNS, GTR, SB	U	(Petrakis and Stergiou 1995)
Synodus saurus	IS	0.007	3.013	Rhodes (Greece)	GNS, GTR	8–35	Present study
S. saurus	IS	0.003 ^{ns}	3.246***	Gulf of Tunis (Tunisia)	GNS, GTR, OTB	U	(Miled-Fathalli et al., 2019)
S. saurus	IS	0.006 ^{ns}	3.064 ***	Southern Ionian Sea (Greece)	GTR, LLS	U	(Dimitriadis and Fournari-Konstantinidou 2018)
S. saurus	IS	0.007 ^{ns}	3.043***	Balearic Isl. and eastern IP (Spain)	GTR, LLS	8–35	(Morey et al. 2003)
S. saurus	IS	0.020 ^{ns}	2.715 ^{ns}	Naxos, Aegean Sea (Greece)	GNS, LLS	U	(Moutopoulos and Stergiou 2002)

Abbreviations: a = intercept, ‘b’ = slope, GNS = gillnet, GTR = trammel net, IB = Iberian Peninsula, LHM = Mechanized line and pole-and-line, LHP = Handline and hand-operated pole-and-line, LLS = longline, MD = mean depth, OTB = bottom otter trawl, PS – purse seine, SB – beach seine, SV – boat seine, TM = midwater trawl, U = unspecified. Significance level: ns = non-significant, * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$)

is at an optimal point. Non-indigenous species appear to be flourishing in their Mediterranean habitat, except for the silver-cheeked toadfish, which displayed negative allometric growth. Conversely, most indigenous species demonstrate isometric growth. The present study indicated, for the first time, an apparent trend of NIS domination. With the employment of the LWRs, we verify that all studied NIS have perfectly adapted and thrive/proliferate in their new environment as has been stated in several works (Arndt et al. 2018; Katsanevakis et al. 2018; Zenetos and Galanidi 2020; Kondylatos et al. 2023a; Vagenas et al. 2023), further supporting the claim that the study area is amongst the regions most affected by biological invasions (Corsini et al. 2017; Kondylatos et al. 2023a, b).

The bogue (*Boops boops*), is the only Sparid among the top 13 demersal fish species caught in the Mediterranean Sea, despite its low commercial value (Fiorentini et al. 1997; Lleonart and Maynou 2003). The estimated slope is statistically different from that of Talet et al. (2017), Mehanna and Farouk (2021) and Falsone et al. (2022) who employed a bottom trawler (OTB) for the collection of ~~their~~ individuals (Table 3). On the contrary, the studies that applied at least one fishing gear as in the present study did not differ significantly from our results (Petrakis and Stergiou 1995; Morey et al. 2003; Özaydin and Taskavak 2006; Ceyhan et al. 2009; Kapiris and Klaoudatos 2011; El Samman et al. 2022; Ragheb 2023), except for Adamidou et al. (2020). This finding depicts a possible relation of the slope with the employed fishing gear, as seen elsewhere (Kasapoglu and Duzgunes 2014).

Regardless of the applied fishing gear, the estimated slope for the wide-eyed flounder (*Bothus podas*), did not exhibit any significant difference (sd) from that estimated in previous studies (Moutopoulos and Stergiou 2002; Morey et al. 2003; Cicek et al. 2006; Özaydn et al. 2007; Karachle and Stergiou 2008; Mehanna and Farouk 2021).

For the common two-banded seabream (*Diplodus vulgaris*), the estimated slope presents no sd with previous studies for the individuals caught with OTB and combinations including OTB (Özaydin and Taskavak 2006; İlkyaz et al. 2008; Mehanna and Farouk 2021) and either sd or no sd for the static nets (Karakulak et al. 2006; Moutopoulos et al. 2013; Adamidou et al. 2020; Gökçe et al. 2007).

Originally occurring in the Indian and Pacific Oceans (Fritzsche 1976; Froese and Pauly 2023), the bluespotted cornetfish is currently one of the most successful invaders of the Mediterranean Sea (Streftaris and Zenetos 2006). In terms of the slope value, our results differ significantly with previous reports based on individuals collected with OTB (Ergüden et al. 2009; Bilge et al. 2014; Vitale et al. 2016; Mehanna and Farouk 2021).

According to Kara et al. (2015), the silver-cheeked toadfish is widely spread in the tropical Indo-West Pacific Ocean, the Red Sea, and more recently, the eastern Mediterranean Sea basin. The species was first reported in the Mediterranean Sea in 2003 from Turkey and ever since it is listed as an invasive species (Akyol et al. 2005; Torcu-Koç et al. 2011; Nader et al. 2012). The negative allometry estimated for the silver-cheeked toadfish combined with the equal or bellow three ‘b’ value in all relevant studies included herein (Aydin 2011; Başusta et al. 2013; Boustany et al. 2015; Aydin et al. 2017; Bilge et al. 2017; Torcu-Koç et al. 2020), is an indication that the species is malnourished, or a fact attributed to the inherited body shape of the species. The possible relation of the type of fishing gear to the slope is not clear since the results in the aforementioned studies were based on individuals collected with a variety of fishing gear not in agreement with that applied herein. The possible implications of the type of fishing gear on the slope warrant further investigation.

The slope in the surmullet did not differ significantly from that estimated in other studies in the Mediterranean. It is worth mentioning that the results of the studies taken under consideration herein were not based on individuals collected with the same, single fishing gear as in our study (Petrakis and Stergiou 1995; Morey et al. 2003; Özaydin and Taskavak 2006; Cicek et al. 2006; İlkyaz et al. 2008; Ceyhan et al. 2009; Moutopoulos et al. 2013; Akel 2016; Talet et al. 2017; Mehanna and Farouk 2021; Falsone et al. 2022; Karadurmuş 2022; Karachle and Stergiou 2008).

In the axillary seabream, the estimated allometry was negative. Our slope was quite lower than three and significantly different from that in all other studies taken under consideration herein. However, the estimation of the LWR was based on individuals of a narrow length range, an attribute to the fishing gear selectivity and/or to the small number of deployments. The importance of the size range of the individuals measured for the estimation of LWR has been pointed out elsewhere (Petrakis and Stergiou 1995).

The estimated slope for the common pandora (*Pagellus erythrinus*), is significantly different from the majority of the studies from the Mediterranean (Morey et al. 2003; Cicek et al. 2006; Chérif et al. 2008;

İlkyaz et al. 2008; Ceyhan et al. 2009; Kapiris and Klaoudatos 2011; Moutopoulos et al. 2013; Falsone et al. 2022; Ragheb 2023). Notably, no sd was demonstrated compared to the studies that included individuals collected from a combination of three to four different fishing gears, two of which are the same as those deployed in our study (Petrakis and Stergiou 1995; Özaydin and Taskavak 2006; Ghailen et al. 2010).

Positive allometry was exhibited for the red porgy (*Pagrus pagrus*). Our slope presents no sd from studies that the individuals were collected with LLS or OTB (İlkyaz et al. 2008; Öztekin et al. 2016; Ayyildiz et al. 2020; Mehanna and Farouk 2021; Falsone et al. 2022) whereas sd was exhibited in a study that used a combination of GTR and LLS (Morey et al. 2003).

For the Red Sea goatfish (*Parupeneus forsskali*), our slope was marginally less than three and higher from that of Sabrah (2015) who employed individuals collected with a combination of three different fishing gears (GNS and GTR as in our study and LLS).

No sd was exhibited for the slopes of the rhomboid sweeper (*Pempheris rhomboidea*), the redcoat (*Sargocentron rubrum*) and the red scorpionfish (*Scorpaena scrofa*) compared to other studies.

The devil firefish exhibited positive allometry, suggesting that the species is thriving in the coastal marine waters of Rhodes. However, we cannot be certain that the population growth of the devil firefish has reached a plateau. Our findings agree with earlier studies from Turkey (Dağhan and Demirhan 2020) and Cyprus (Savva et al. 2020) that have employed different and/or unspecified fishing gear.

The dusky spinefoot exhibited positive allometry with a slope significantly different (higher) than that of earlier studies from Turkey (Ceyhan et al. 2009; Ergüden et al. 2009; Begburs and Kebapcioglu 2013; Türker et al. 2020), suggesting that the species is thriving in Rhodian waters, even better than other areas of the eastern Mediterranean. Interestingly, none of the aforementioned studies employed exactly the same fishing gear for the collection of the dusky spinefoot individuals. On the other hand, the marbled spinefoot (*Siganus rivulatus*), one of the Lessepsian migrants that invaded the Mediterranean (Ben-Tuvia 1975) and turned into a commercial alien fish for small-scale coastal fishery (Saoud and Ghanawi 2010), exhibited isometric allometry. Our findings were in accordance with all ~~the~~ investigated studies form the Mediterranean (Bilecenoglu and Kaya 2002; Ceyhan et al. 2009; Ergüden et al. 2009; Begburs and Kebapcioglu 2013; Türker et al. 2020; Mehanna and Farouk 2021; Ragheb 2023), none of which employed individuals collected with the same combination of fishing gears as in the present study.

The slope for the yellow-stripe barracuda exhibited sd in comparison with the values reported in Ergüden and Ozdemir (2022) from Turley and in ElGanainy et al. (2017) from the Gulf of Suez.

The parrot fish (*Sparisoma cretense*), is only significant to commercial fisheries in the Dodecanese Islands, Greece, as an incidental species (Petrakis and Papaconstantinou 1990). Our findings showed that the species exhibited isometric growth, in contrast to those of Moutopoulos and Stergiou (2002) and Miled-Fathalli et al. (2019), who found a negative allometric growth and with those of Dimitriadis and Fournari-Konstantinidou (2018) who reported positive allometric growth for individuals collected with GTR and LLS.

The blotched picarel exhibited negative allometry in agreement with Petrakis and Stergiou (1995), Özaydin and Taskavak (2006), Chérif et al. (2008), Adamidou et al. (2020) and Evagelopoulos et al. (2020). In contrast, several authors have reported significantly higher positive allometry (Moutopoulos and Stergiou 2002; Morey et al. 2003; Cicek et al. 2006; İlkyaz et al. 2008; Karachle and Stergiou 2008; Dimitriadis and Fournari-Konstantinidou 2018; Miled-Fathalli et al. 2019; Mehanna and Farouk 2021). The individuals employed in most of these studies were collected with various combinations of two to four fishing gears.

Interestingly, the estimated slope for ~~the species~~ picarel (*Spicara smaris*), did not exhibit sd with any of the listed studies in Table 3, that applied various combinations of fishing gears, none of which was identical to the present study.

For the Atlantic lizardfish (*Synodus saurus*), the slope was significantly different from published literature, where the individuals were caught with combinations of fishing gear which all involved the employment of GTR.

Because of the size-selective features of the applied fishing gear, our samples did not include relatively small-sized individuals resulting in LWRs limited to the observed length ranges (Petrakis and Stergiou 1995; Gonçalves et al. 1997). Estimated parameters for the total population of each species have significant importance for fisheries management since no gears are sex selective, at least for fish, with all fisheries restrictions applying to the entire stock or population. Most of the species were collected over a length of time; therefore, the data were not indicative of a specific season or time of the year, thus representing mean annual values.

Our findings can facilitate regional stock assessments and serve as a baseline for future comparisons in other Mediterranean areas using an analogous methodology. Continuous monitoring of demersal habitats is crucial for fish stock sustainability and biodiversity preservation. In a constantly changing ecosystem like the Mediterranean Sea, assessing the changes induced by invasive species is critical and LWRs constitute an important tool for stock assessment and population dynamics.

Conclusions

In fisheries science, LWR is a vital technique that is utilized to measure biomass, total catch, or length-frequency samples. It is also an important instrument for comprehending fish biology, physiology, ecology, stock evaluation, and population dynamics. Allometric data of marine fish species from the study area are scarce and imperative in assessing the ongoing changes of small-scale fisheries in Rhodian coastal marine waters, a highly affected region of the Eastern Mediterranean by biological invasions. The information provided herein will allow future population comparisons and assist in the management and conservation efforts aiming in the population monitoring and control of NIS. Interestingly, in our study the only species that exhibited statistically significant positive allometric relationships were three NIS, namely the invasive bluespotted cornetfish, the devil firefish and the dusky spinefoot.

Competing interests The authors declare that they have no competing interests.

Author contributions Conceptualization: G.K.; methodology: G.K.; software: G.K., I.K.; validation: G.K.; formal analysis: G.K., I.K., M.A. and D.K.; investigation: G.K. and A.T.; resources: G.K. and I.K.; data curation: G.K., A.T., A.C. and D.K; writing—original draft preparation: G.K., I.K., D.V., A.E., A.T., A.C. and D.K.; writing—review and editing: G.K., I.K., D.V., A.E., A.T., D.M., K.K., M.A., and A.C.; visualization: G.K., A.T. and D.K.; supervision: D.K.; project administration: G.K.; funding acquisition: G.K. All authors have read and agreed to the published version of the manuscript.

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