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WEIGHT–LENGTH RELATIONSHIPS OF FISHES DISCARDED BY TRAWLERS IN THE NORTH AEGEAN SEA

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Background. Weight–length relationships of discarded species can de used for the estimation of discarded quantities per species, if the species' length-frequency distribution is known. In this study, we present weight–length for 26 fish species discarded by commercial trawlers.

Material and methods. We present weight–length relationships ($W = a\mathrm{TL}^b$), for 26 discarded fish species, from samples caught with commercial trawlers (diamond cod-end mesh size: 14 mm; nominal bar length), from October 1996 to May 1998 in the North Aegean Sea.

Results. The values of the exponent b of the weight–length relationships of the 26 fish species differed between years for six species and ranged from 1.507 to 3.596 (median and mean: 3.068 and 2.968 respectively).

Conclusion. Weight–length relationships for 5 out of the 26 fish species are presented for the first time.

Key words: fish, weight–length relationships, discards, Thracian Sea, Aegean Sea

INTRODUCTION

In this study we report weight–length relationships ($W = a\mathrm{TL}^b$) for 26 fish species, discarded from trawlers in the Thracian Sea (Greece), for five of which there has hitherto been no information available on their length–weight relationships (see also Froese and Pauly 2003).

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These weight–length relationships can be used, among other reasons (see Gonçalves et al. 1996, Martin-Smith 1996, Froese and Pauly 2000, Moutopoulos and Stergiou 2002, Morey et al. 2003), for the estimation of discarded quantities per species, if the species' length–frequency distribution is known. Although all gear types produce discards, which is a major source of uncertainty in fisheries management (Hall 1999), trawling is characterized by the highest discarding rate in Greek waters when compared with other gears (i.e. > 45% of the total catch: Stergiou et al. 1997, Machias et al. 2001).

MATERIALS AND METHODS

Commercial fishing was conducted in the North Aegean Sea (Thracian Sea) (39°35'–40°54'N; 24°22'–25°33'E) during 1996–1998 using two commercial trawlers (diamond cod-end mesh size: 14 mm; nominal bar length), at depths ranging from 19 to 356 m. Samples were collected in autumn, winter and spring during the open trawling season. All discarded specimens were sorted to the species level onboard. The most abundant species were measured for total length (TL, in mm) and weighed (fresh weight, W, in g) in the laboratory. The parameters a and b of the weight–length relationship ($W = a\mathrm{TL}^b$) were calculated for each species using least-squares regression after log transformation of the two variables ($\log_{10}W = \log_{10}a + b\log_{10}\mathrm{TL}$).

Weight–length relationships were estimated separately by study year (1996–1997 and 1997–1998) and for the ten most abundant species separately by season (autumn, winter, and spring). The slopes of the regressions were compared between years and seasons using analysis of covariance (ANCOVA) (Zar 1999). Separate relationships were presented only in the case of significant ($P < 0.05$) difference between years and seasons.

RESULTS AND DISCUSSION

We present weight–length relationships for 26 fish species (based on 17 352 specimens). The sample size, minimum and maximum TL, regression parameters a and b, standard error of b, and coefficient of determination r^2 are shown in Table 1. For all relationships, regression hypotheses were met and r^2 were higher than 0.778 ($P < 0.001$). The values of b ranged from 1507, for red bandfish, *Cepola macrophthalma* (L.) for 1996–97, to 3596 for grey wrasse, *Symphodus cinereus* (Bonnaterre, 1788) for 1997–1998 (median and mean: 3.02 and 2.89, respectively). The values of a ranged from 0.0001, for greater pipefish, *Syngnathus acus* L., to 0.1039, for boarfish, *Capros aper* L. in 1997–1998 (median and mean: 0.0085 and 0.01875 respectively).

The slope b differed significantly with year (ANCOVA; $P < 0.05$) for six species (i.e. argentine, *Argentina sphyraena* L.; *Capros aper*; *Cepola macrophthalma*; large-scaled gurnard, *Lepidotrigla cavillone* (Lacepède, 1801); brown comber, *Serranus*

hepatus L.; and *Symphodus cinereus*) out of the 26 species studied. The absolute difference of the parameter *b* of the relationships between the two sampling years (1996–1997 and 1997–1998) for these six species ranged from 0.1154, for *Cepola macrophthalma*, to 0.9126 for *Capros aper* (Table 1).

The weight–length relationships of the 10 most abundant fish species (*Argentina sphyraena*; Thor's scaldfish, *Arnoglossus thori* Kyle, 1913; Butterfly blenny *Blennius ocellaris* L.; *Capros aper*; *Cepola macrophthalma*; four-spotted goby *Deltentosteus quadrimaculatus* (Valenciennes, 1837); *Lepidotrigla cavillone*; Fries's goby *Lesueurigobius friesii* (Malm, 1874); *Serranus hepatus*; and tonguesole *Symphurus nigrescens* Rafinesque, 1810) were estimated separately for autumn, winter, and spring. The slope *b* differed significantly with season (ANCOVA; $P < 0.05$) for four species only (Table 2).

Within- and between year differences in *b* values can be the result of differences in the number and observed length ranges of specimens examined between the two sampling years (mainly for *Argentina sphyraena, Cepola macrophthalma,* and *Serranus hepatus*: Table 1) and seasons (mainly for *Argentina sphyraena*, *Arnoglossus thori*, and *Capros aper*; Table 2) and/or of temporal differences in food availability and species' life history (i.e. spawning period and gonad development) (e.g. Weatherly and Gill 1987, Wootton 1990).

Table 1

Parameters of the relationships ($W = aTL^b$) between total weight (W, in g) and total length (TL, in cm) for 26 discarded fish species, collected from October 1996 to May 1998 per year and two sampling years combined, in the Thracian Sea; species are listed in alphabetic order

Species	Year	*N*	TLmin	TLmax	*a*	*b*	SE(b)	r^2	$\lvert b_{96-97} - b_{97-98} \rvert$
Argentina sphyraena[2]	1996–98	1093	4.8	18.2	0.0040	3.124	0.024	0.941	
Argentina sphyraena	1996–97	327	5.0	15.6	0.0052	3.023	0.061	0.884	0.2122
Argentina sphyraena	1997–98	766	4.8	18.2	0.0030	3.235	0.026	0.954	
Arnoglossus rueppelii[2]	1996–98	72	5.5	15.7	0.0077	2.880	0.050	0.979	
Arnoglossus thori[2]	1996–98	572	3.8	12.6	0.0060	3.151	0.035	0.934	
Atherina boyeri[2]	1996–98	149	6.2	11.4	0.0040	3.189	0.065	0.942	
Blennius ocellaris[2]	1996–98	117	5.3	14.1	0.0161	2.959	0.049	0.970	
Callionymus fasciatus	1996–98	18	6.0	16.6	0.0080	2.863	0.232	0.905	
Callionymus reticulatus	1996–98	58	4.1	7.6	0.0206	2.379	0.159	0.800	
Callionymus risso	1996–98	22	4.3	14.7	0.0065	3.059	0.069	0.990	
Capros aper[2,3]	1996–98	203	2.9	12.2	0.0279	2.762	0.060	0.912	
Capros aper	1996–97	183	2.9	8.0	0.0196	2.968	0.053	0.945	0.9126
Capros aper	1997–98	20	3.6	12.2	0.1039	2.056	0.189	0.868	
Cepola macrophthalma[1,3]	1996–98	1021	10.3	53.2	0.0863	1.543	0.031	0.796	
Cepola macrophthalma	1996–97	683	11.2	53.2	0.0971	1.507	0.040	0.778	0.1154
Cepola macrophthalma	1997–98	338	10.3	49.5	0.0666	1.622	0.024	0.831	
Coris julis[1,3]	1996–98	15	7.6	13.7	0.0063	3.125	0.259	0.918	
Deltentosteus quadrimaculatus[2,3]	1996–98	1010	4.3	10.3	0.0038	3.368	0.030	0.928	
Gadiculus argenteus argenteus[1,3]	1996–98	102	4.9	10.0	0.0088	2.966	0.127	0.844	
Gaidropsarus mediterraneus[1]	1996–98	32	7.1	16.0	0.0144	2.608	0.208	0.839	

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Table 1

(continuation)

Species	Year	*N*	TLmin	TLmax	*a*	*b*	SE(b)	r^2	$\lvert b_{96-97}-b_{97-98}\rvert$
Gobius cruentatus[3]	1996–98	39	6.7	17.1	0.0096	3.036	0.092	0.967	
Lepidotrigla cavillone[1]	1996–98	827	3.6	13.0	0.0081	3.157	0.024	0.960	
Lepidotrigla cavillone	1996–97	565	3.6	12.9	0.0068	3.241	0.053	0.969	0.3763
Lepidotrigla cavillone	1997–98	262	4.4	13.0	0.0155	2.865	0.022	0.919	
Lesueurigobius friesii[2]	1996–98	477	3.6	10.0	0.0077	3.006	0.040	0.921	
Lesueurigobius suerii	1996–98	23	3.9	7.5	0.0155	2.561	0.201	0.885	
Macroramphosus scolopax[2,3]	1996–98	19	6.1	12.6	0.0229	2.426	0.148	0.941	
Ophidion barbatum	1996–98	45	10.1	24.0	0.0027	3.183	0.130	0.933	
Parablennius gattorugine[2]	1996–98	12	6.2	10.5	0.0106	2.884	0.187	0.960	
Serranus hepatus[1,3]	1996–98	2318	2.9	12.1	0.0121	3.122	0.016	0.951	
Serranus hepatus	1996–97	1739	2.9	11.6	0.0113	3.157	0.049	0.960	0.4125
Serranus hepatus	1997–98	579	4.6	12.1	0.0267	2.745	0.015	0.842	
Symphodus cinereus[1,3]	1996–98	196	4.4	11.2	0.0057	3.396	0.065	0.959	
Symphodus cinereus	1996–97	119	4.4	11.2	0.0071	3.284	0.075	0.956	0.3119
Symphodus cinereus	1997–98	77	5.0	10.1	0.0039	3.596	0.050	0.969	
Symphurus nigrescens[3]	1996–98	406	4.7	13.0	0.0029	3.452	0.049	0.924	
Syngnathus acus[2]	1996–98	47	14.9	33.6	0.0001	3.423	0.161	0.910	
Torpedo marmorata[3]	1996–98	25	9.6	28.5	0.0273	2.898	0.088	0.979	

N, sample size; TLmin and TLmax, minimum and maximum TL [cm], respectively; *a* and *b*, parameters of the relationship; SE(*b*), standard error of parameter *b*; r^2, coefficient of determination; and $|b_{96-97}-b_{97-98}|$, absolute difference of the parameter *b* between the two sampling years (1996–1997 and 1997–1998) for the species for which the slopes *b* differed significantly (ANCOVA, $P < 0.05$)

[1] species included in Stergiou and Moutopoulos (2001)

[2] species having at least one reference in FishBase (Froese and Pauly 2003)

[3] species included in Morey et al. (2003)

Table 2

Parameters of the relationships ($W = a\mathrm{TL}^b$) by season between total weight (W, in g) and total length (TL, in cm) for fish species for which the slopes b differed significantly (ANCOVA, $P < 0.05$) with season; species are listed in alphabetic order

Species	Season	N	TLmin	TLmax	a	b	SE(b)	r^2
Argentina sphyraena	Autumn–Winter	509	7.3	18.2	0.00555	2.997	0.033	0.943
	Spring	584	4.8	15.1	0.00312	3.219	0.032	0.945
Arnoglossus thori	Autumn–Winter	482	3.8	11.5	0.00727	3.049	0.043	0.914
	Spring	90	5.6	12.6	0.01887	2.676	0.104	0.884
Capros aper	Autumn	15	4.0	12.2	0.04512	2.498	0.148	0.956
	Winter	134	2.9	8.0	0.01658	3.079	0.052	0.964
	Spring	54	3.6	7.4	0.12391	1.916	0.182	0.681
Deltentosteus quadrimaculatus	Autumn	719	4.7	10.0	0.00455	3.294	0.034	0.928
	Winter	229	4.3	9.3	0.00295	3.478	0.057	0.943
	Spring	62	4.5	10.3	0.01051	2.844	0.137	0.878

N, sample size; TLmin and TLmax, minimum and maximum TL in cm, respectively; a and b, parameters of the relationship; SE(b), standard error of parameter b; and r^2, coefficient of determination

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