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ORIGINAL ARTICLE

Distribution and biological features of the common pandora, *Pagellus erythrinus* (Linnaeus, 1758), in the southern Tyrrhenian Sea (Central Mediterranean)

B. Busalacchi · T. Bottari · D. Giordano · A. Profeta · P. Rinelli

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Abstract A synthetic analysis of the distribution, abundance and some biological traits of the common pandora (*Pagellus erythrinus*) was performed. Data were gathered in 15 experimental bottom trawl surveys carried out off the southern Tyrrhenian Sea from 1994 to 2008. A total of 2,166 *P. erythrinus* were found in the investigated area, with a preference for the upper continental shelf (10–100 m). The highest persistence was recorded in the trawl-banned areas. The sex ratio $Sr = F/(F + M)$ ranged between 0.60 and 0.96 (overall 0.78). The size at which 50 % of the individuals were mature was 157 and 170 mm total length for females and males, respectively. The length–weight relationship for all individuals was described by the following parameters: $a = 0.016$ and $b = 2.905$. Growth was evaluated (sexes combined) by applying length-based methods; up to eight significant modal components were evidenced. The von Bertalanffy growth parameters for the whole population were estimated at $L_\infty = 454$ mm, $K = 0.08$ and $t_0 = -2.57$. The present results are in agreement with the information available for the other Mediterranean stocks suggesting common biological features.

Keywords *Pagellus erythrinus* · Distribution · Biological traits · Growth · Mediterranean Sea

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B. Busalacchi (✉) · T. Bottari · D. Giordano · A. Profeta · P. Rinelli
Institute for Coastal Marine Environment (IAMC), National Research Council (CNR), Spianata S. Raineri 86, 98122 Messina, Italy
e-mail: barbara.busalacchi@iamc.cnr.it

Introduction

The common pandora *Pagellus erythrinus* (Linnaeus 1758) is a gregarious demersal species living on rocky and muddy–sandy bottoms, between 20 and 300 m depth (Bauchot and Hureau 1986; Santos et al. 1995). It occurs in the eastern Atlantic from Norway to Angola including the Mediterranean and Black Seas (Bauchot and Hureau 1986; Froese and Pauly 2014).

Standard length (SL) of individuals can reach a maximum of 600 mm but most frequently range from 100 to 300 mm (Froese and Pauly 2014).

The species shows protogynous hermaphroditism (Girardin and Quignard 1985; Papaconstantinou et al. 1988; Livadas 1989; Pajuelo and Lorenzo 1998); females usually become males from the second to the third year at sizes of 170–180 mm total length (TL; Relini et al. 1999). However, the sexual pattern seems to be much more complex as both primary males and specimens, which are still females at the known maximum size, are frequently identified (Larrañeta 1964). The spawning season lasts from March to November in the Mediterranean Sea and from May to August in the Atlantic waters (Hashem and Gassim 1981; Girardin and Quignard 1985; Papaconstantinou et al. 1988; Livadas 1989; Pajuelo and Lorenzo 1998; Hoşsucu and Çakır 2003; Coelho et al. 2010; Tsikliras et al. 2010). Sexual maturity is reached between the second and the third year of life (Girardin and Quignard 1985; Pajuelo and Lorenzo 1998). The species can be considered a generalist predator; it feeds on Decapoda, Bivalvia, Polychaeta, Euphausiacea, Teleostei, Mysidacea and Cephalopoda (Ardizzone and Messina 1983; Šantić et al. 2011).

Pagellus erythrinus is an appreciated fishery resource in the Mediterranean and Atlantic waters (Erzini et al. 1998; Abellán and Basurco 1999). Signs of overexploitation of

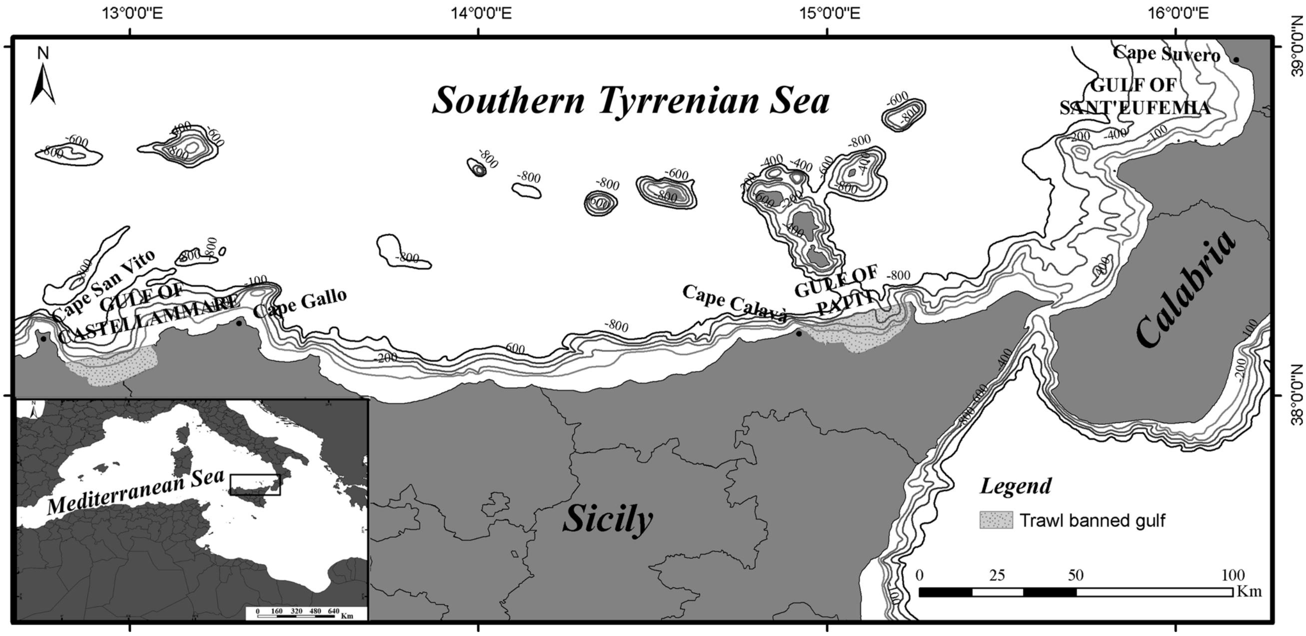

Fig. 1 Map of the study area showing the trawl banned areas of the Gulfs of Castellammare and Patti

the species' standing stock have been reported in diverse Mediterranean geographical sub-areas (GSAs) (Vassilopoulou et al. 1986; Jarboui et al. 1998; Abella et al. 2010; Mehanna 2011; Gurbet et al. 2012) and also in Sicilian waters (Fiorentino et al. 2012). In Italy, *P. erythrinus* is one of the most common landed seabreams, although total landings have declined in recent years from a total of approximately 1,900 t in 2004 to 850 t in 2010 (IREPA 2011). In the Mediterranean Sea, the current conservation legislation on fisheries sets the minimum size limit for this species at 150 mm TL (EU Regulation 1967/2006).

There is little published information on *P. erythrinus* for the southern Tyrrhenian Sea (Spedicato et al. 2002; Busalacchi et al. 2010; Giacalone et al. 2010) where it plays an important role in the demersal fish community of the upper continental shelf area (10–100 m) (Busalacchi et al. 2010).

In the present paper, we present a synthetic analysis of the distribution, abundance and biological traits of the common pandora in the southern Tyrrhenian Sea using data from experimental bottom trawl surveys.

Materials and methods

Data here reported come from 15 bottom trawl surveys carried out during the "International Bottom Trawl Survey in the Mediterranean" (MEDITS Project) in late spring–summer periods from 1994 to 2008. The study area extended from Cape Suvero to Cape S. Vito (Fig. 1), at depths of 10–800 m, covering a total area of 7,256 km^2. The sea floor of this area is characterized by a narrow, sometimes nearly missing continental shelf, and by a steep slope with spatial contiguity to the bathymetrics. Only 65 % (4,716 km^2) of the total area can be trawled by commercial vessels because the Gulf of Castellammare and the Gulf of Patti have been stated Fishery Exclusion Zones in 1990. Trawl fishing is banned on the continental shelf and part of the slope, i.e. for 200 km^2 of the Castellammare Gulf and for the whole area (242 km^2) of the Patti Gulf; artisanal and recreational fishing are permitted.

Sampling procedures were the same in all surveys, according to the MEDITS project protocol (Relini et al. 2008). Sampling was carried out randomly, and the hauls were proportionately distributed in five bathymetric strata: 10–50 m (622 km^2), 51–100 m (1,003 km^2), 101–200 m (1,224 km^2), 201–500 m (1,966 km^2) and 501–800 m (2,441 km^2). A total of 383 hauls were carried out. As the species was found almost exclusively in the first three bathymetric strata (Table 1), all data analysis refers to this bathymetric interval. An experimental sampling gear with a cod-end mesh size of 20 mm was used. The fishing speed was 3 knots. The horizontal and vertical openings of the net (on average 18.4 and 1.90 m, respectively) were measured using a SCAMMAR system.

Each sampled specimen was measured (total length: TL, mm), weighted (total weight: TW, g) and dissected in order to expose the internal body cavity for a macroscopic (i.e. by naked eye) evaluation of sex (females, males and unsexed juveniles). Specimens were classified in four

Table 1 Distribution of the number of hauls for each survey and depth stratum

Depth stratum (m)	Survey														
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
0–50	3	4	4	4	4	4	4	4	3	3	3	3	3	3	3
51–100	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3
101–200	6	6	6	6	6	6	6	6	5	5	5	5	5	5	5

macroscopic maturity stages as follows: first—immature, second—maturing, third—mature and fourth—spent (Bertrand et al. 1999). Given the low incidence of transitional hermaphroditic stage, these specimens were excluded from further analyses.

Mean Density Index (DI; N/km^{-2}) and Biomass Index (BI; kg/km^{-2}) were estimated (for each stratum and overall area) according to the swept-area principle (Gunderson 1993). Frequency of occurrence (f) was also computed as percentage of positive hauls (presence of at least 1 specimen). The temporal correlation in DI and BI was evaluated ($p < 0.05$) by computing the Spearman nonparametric rank coefficient (r_s). Data were tested for normality and homogeneity of variance with Shapiro–Wilk and Levene's tests, respectively. As a consequence of the non-normality of the DI and BI data sets even after log-transformation, the Kruskal–Wallis test was applied to compare the median values of DI and BI between depth strata (Sokal and Rohlf 1995).

The spatial analysis of the common pandora distribution was performed using geostatistical methods. Single hauls data were used to generate annual distribution maps of DI through the deterministic technique, inverse distance weighting (IDW) (Isaaks and Srivastava 1989).

Density hot spots were outlined on the annual maps using a threshold calculated on the basis of the cumulative distribution of the DI_s. The DI_s per haul were sorted in descending order, a cumulative-frequency distribution computed, and the percentile values of the series estimated. The density corresponding to the third quartile of this distribution, i.e. encompassing 75 % of the cumulative density, was selected as the cut-off value to identify the density hot spots (Fiorentino et al. 2003; Garofalo et al. 2011).

To assess the spatiotemporal stability of the density hot spots, a persistence index (PI; Garofalo et al. 2011) was calculated by overlapping the maps of the whole time series and counting, on a cell-by-cell basis (1 km × 1 km), the number of times a given area was classified as an annual density hot spot. This index was obtained as a ratio of the number of times a given area was classified as a hot spot to the total number of years. The PI ranged between 0 and 1, with 0 indicating "hot spots absence" and 1 indicating "stable hot spot". A minimum threshold of 0.6 was considered to define persistent density hot spots (PI $\geq$ 0.60).

The relationship between fish length and depth was also investigated. Minimum, maximum and median lengths were calculated by depth interval (50 m each) and graphically represented by box plots. To test the correlation between median length and depth, the Spearman's rank correlation method was applied.

The sex ratio (Sr), overall and by length class (10 mm), was defined as the proportion of females on the total sexed individuals. The potential difference between observed and expected Sr (0.5) was evaluated with a χ^2 test.

Maturity structure was analysed using the box plot representation approach (medians by maturity stages) separately for females and males. The size at the onset of sexual maturity (TL at which 50 % of the individuals are mature), herein defined as L_m, was derived according to the logistic approach:

$$p_{ak} = \frac{1}{1 + \exp -g * (L_k - L_m)}$$

where p_{ak} represents the proportion of the mature specimens (from second to fourth stage) in length class intervals L_k (10 mm), and g is the steepness parameter of the maturity curve (Lysack 1980).

The relationship between fish TL and total weight was calculated for females, males and the sexes combined. Weights and TLs data were log-transformed; the linear relationship fitted by least square regression was used to calculate the coefficients a and b. The linear regression assumptions were checked by performing the analysis of residuals; the departure from the isometric condition (H_0: $b = 3$) was tested by Student's t test, and differences between sexes were tested by an analysis of covariance (Sokal and Rohlf 1995). All the statistic analyses were performed in the Mystat software (Wong 1989).

Length frequency distributions (LFDs) for each year were computed. LFDs were resolved into Gaussian components with Bhattacharya's method implemented in the software package FISAT II (Gayanilo et al. 2005). The von Bertalanffy growth model was fitted after having assembled a series of length-at-age data assigning a putative age (years) at each group on the base of an overall interpretation of the life cycle. To compare performance of the stocks, the phi-prime index (Φ') was calculated (Pauly and Munro 1984), thus overcoming the problem of the correlation between k and L_∞.

Results

A total of 2,166 (482 males, 1,664 females, 8 hermaphrodites and 12 undetermined) *P. erythrinus* were sampled, ranging in length from 55 to 480 mm.

Species showed a marked preference for the upper continental shelf with the highest abundance observed between 10 and 50 m ($f = 97$ %, DI = 530, BI = 64). The difference of DI and BI values between depth strata was significant ($H = 28.29$ and $p < 0.01$ for DI; $H = 27.48$ and $p < 0.01$ for BI). The temporal changes of the overall mean DI showed a significant negative trend ($r_s = -0.55$ and $p < 0.05$; Table 2). No temporal trend of BI values was observed ($r_s = -0.48$ and $p > 0.05$) (Table 3).

Pagellus erythrinus was distributed widely in the study area. Its most persistent grounds in the southern Tyrrhenian

Table 2 Density index (N/km^2), standard deviation (SD), coefficient of variation (CV) and frequency of occurrence (*f*) of *P. erythrinus* by stratum and in the overall bathymetric range for each survey

Depth	Density index (N/km^2)	Survey														
		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
10–50 m	Mean	140	412	626	445	443	446	183	1028	1378	1605	388	239	371	159	94
	SD	7	125	239	138	139	104	37	325	487	499	34	26	9	27	12
	CV %	5	30	38	31	31	23	20	32	35	31	9	11	2	17	12
	f	100	100	75	75	100	100	100	100	100	100	100	100	100	100	100
51–100 m	Mean	777	232	376	665	235	295	489	456	361	194	63	264	134	299	120
	SD	227	91	158	236	93	99	158	152	83	49	8	106	28	115	6
	CV %	29	39	42	35	39	34	32	33	23	25	12	40	21	38	5
	f	50	50	25	50	50	100	100	100	100	100	100	33	67	67	100
101–200 m	Mean	67	140	0	0	45	19	64	35	0	0	0	15	27	11	12
	SD	36	68	0	0	20	11	18	14	0	0	0	6	10	4	6
	CV %	54	49	0	0	44	58	27	41	0	0	0	38	36	34	50
	f	33	67	0	0	50	17	67	50	0	0	0	40	40	40	20
10–200 m	Mean	278	240	272	304	205	204	214	420	452	449	114	142	144	128	64
	SD	134	89	149	146	89	81	88	195	255	274	40	56	36	60	13
	CV %	48	37	55	48	43	40	41	46	56	61	35	40	25	47	21
	f	54	71	29	36	64	64	86	79	55	55	55	55	64	64	64

Table 3 Biomass index (kg/km^2), standard deviation (SD) and coefficient of variation (CV) of *P. erythrinus* by depth and in the overall bathymetric range for each survey

Depth	Biomass index (kg/km^2)	Survey														
		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
10–50 m	Mean	6.2	24.3	65.9	56.7	25.0	29.2	69.4	96.2	210.4	268.0	31.3	20.0	27.3	13.3	20.3
	SD	0.2	7.8	26.4	20.1	6.8	7.0	21.2	35.0	74.9	80.2	2.6	3.2	2.5	2.5	5.9
	CV %	3.7	32.3	40.2	35.4	27.3	23.9	30.6	36.3	35.6	29.9	8.4	15.9	9.1	19.1	29.1
51–100 m	Mean	63.8	24.7	48.3	73.2	31.7	36.6	55.0	64.6	50.3	9.9	5.9	38.0	13.4	24.5	10.5
	SD	17.9	10.4	20.2	26.4	12.7	13.2	18.7	23.9	15.7	2.8	0.2	15.3	3.3	9.5	0.8
	CV %	28.1	42.1	41.9	36.1	40.0	36.1	34.0	37.0	31.2	28.5	3.0	40.3	24.7	38.9	7.7
101–200 m	Mean	5.7	15.3	0.0	0.0	5.7	2.7	6.6	4.2	0.0	0.0	0.0	1.2	4.0	1.3	1.4
	SD	3.1	7.4	0.0	0.0	2.5	1.6	1.8	1.2	0.0	0.0	0.0	0.5	1.6	0.6	0.7
	CV %	53.4	48.3	0.0	0.0	43.9	57.7	27.7	29.9	0.0	0.0	0.0	40.6	38.9	42.7	50.2
10–200 m	Mean	21.8	20.4	31.1	35.6	18.2	18.8	36.9	45.9	67.7	68.8	9.4	16.4	12.5	10.7	8.8
	SD	10.8	7.8	17.2	17.5	7.5	8.0	15.0	22.2	39.3	44.8	3.2	7.9	3.0	5.0	3.3
	CV %	49.5	38.3	55.5	49.3	41.5	42.8	40.7	48.3	58.1	65.0	33.6	48.2	24.4	46.6	37.1

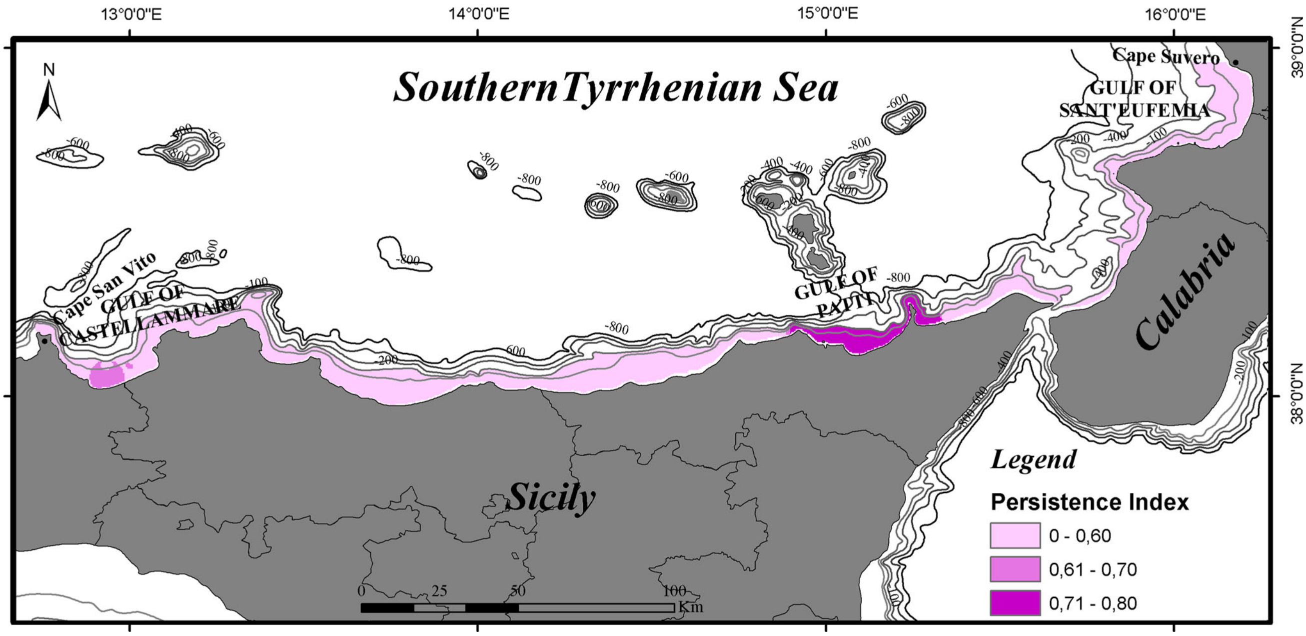

Fig. 2 Spatial distribution of persistent (PI > 0.6) grounds of *Pagellus erythrinus* in the southern Tyrrhenian Sea

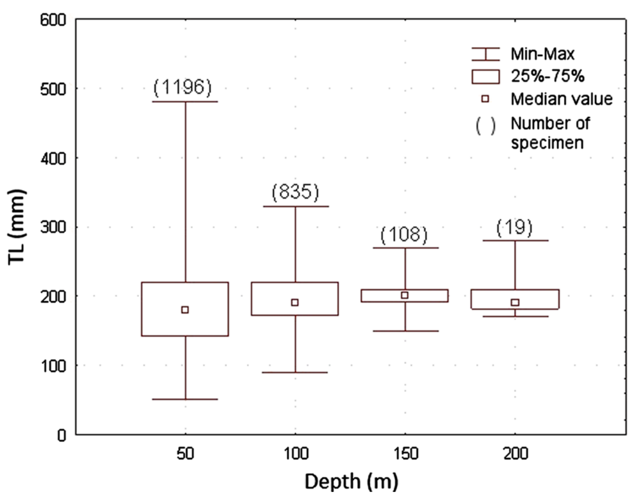

Fig. 3 *Box plot* presentation of the overall total length (all years combined) of *P. erythrinus* by depth interval; TL (minimum, maximum, median, upper and lower quartiles); number of specimens (in *brackets*)

Sea are shown in Fig. 2. Persistent grounds (PI > 0.6) were identified along the northern Sicilian coasts: one area was located in the Castellammare Gulf and another one included the Patti Gulf and immediately adjacent areas.

The box plot representation of size at different depth (Fig. 3) showed a decrease of size range from 50 to 150 depth stratum, followed by a slight increase in 200 m depth stratum. However, median sizes were very similar along the depth classes; in fact, the comparison of median size versus depth confirmed the lack of any significant depth-size effect ($r_s = 0.63$ and $p > 0.05$).

Total length of females ranged between 100 and 460 mm and TL of males between 90 and 480 mm. The overall average sex ratio was 0.78, ranging between 0.60 and 0.96 (Table 4). The results of χ^2 tests revealed significant differences ($p < 0.01$) between expected (0.5) and recorded values of Sr in all years. Moreover, females predominated in length classes between 110 and 240 mm TL (χ^2 from 9.8 to 137.6; $p < 0.05$) and males predominated in the length class 350 mm TL ($\chi^2 = 18$; $p < 0.05$) (Fig. 4). The statistical analysis showed a significant correlation between size class on Sr ($r_s = -0.49$, $p < 0.01$).

The box plot representation of size at different macroscopic maturity stages shows that in adult stages (second to fourth stage), the medians of TL were rather similar among each other, but higher than in the first stage (Fig. 5). A slight difference was detected between the sexes, both for adult stages (males 240–275 mm and females 190–230 mm) and juveniles (males 160 mm and females 140 mm). The TL at which 50 % of the individuals were mature (size at maturity, L_m) was 157 and 170 mm for females and males, respectively. The logistic fit was quite satisfactory for the mature proportion in both sexes (Fig. 6).

Pagellus erythrinus females showed a significant negative allometry ($b < 3$; Table 5). Slight but highly significant differences were detected between males and females ($p < 0.01$), i.e. males had a higher weight than females of similar length. The length–weight relationship for all individuals was described by the following parameters: $a = 0.016$ and $b = 2.905$.

The TL of the specimens ranged from 55 to 480 mm (Fig. 7). Length frequency distribution shape showed

Table 4 Sex ratio (Sr) evolution by time for *P. erythrinus*, and corresponding χ^2 test results

Parameter	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total
No. females	135	141	132	167	117	131	99	222	152	130	46	56	53	49	28	1658
No. males	25	18	42	28	14	6	40	47	76	86	14	23	18	21	4	462
Mean (Sr)	0.84	0.89	0.76	0.86	0.89	0.96	0.71	0.83	0.67	0.60	0.77	0.71	0.75	0.70	0.88	0.78
Variance (Sr)	0.03	0.03	0.03	0.03	0.03	0.02	0.04	0.02	0.03	0.03	0.05	0.05	0.05	0.05	0.06	0.01
χ^2 value	74.26	93.61	45.52	97.66	79.42	112.23	24.20	112.55	24.67	8.56	16.02	12.96	16.28	10.41	16.53	674.72
χ^2 significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

** Statistic significant χ^2 (at $p < 0.01$)

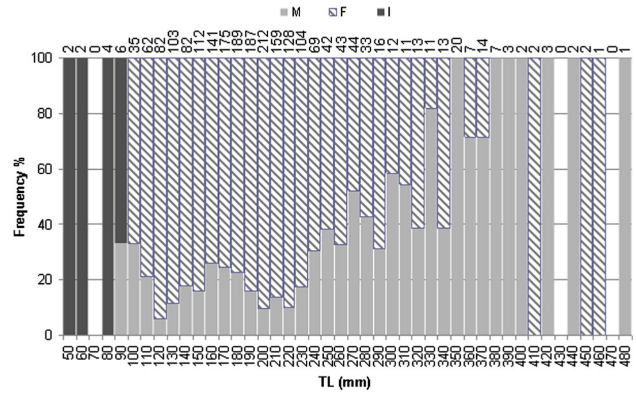

Fig. 4 Frequency (%) of females (F), males (M) and unsexed juveniles (I) of *P. erythrinus* in different length classes. *TL* total length. The number of specimens for each length class are given above the *bars*

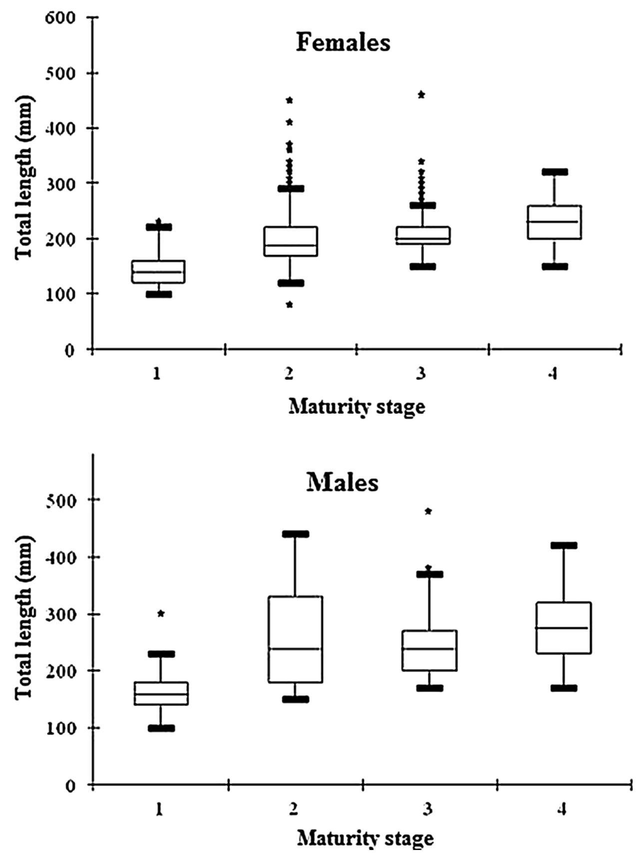

Fig. 5 *Box plot* presentation of the overall total length (years combined) of *P. erythrinus* by maturity stage for females and males. *Asterisks* indicate outliers

multiple overlapping modes and a prevalence of medium size specimens. Implementing the FISAT procedures, the Bhattacharya analysis allowed the identification of up to 8 modal groups. Hence, the von Bertalanffy growth function (sexes combined) was chosen, resulting in estimations of $TL_\infty = 454$ mm, $K = 0.08$ and $t_0 = -2.57$ (Fig. 8).

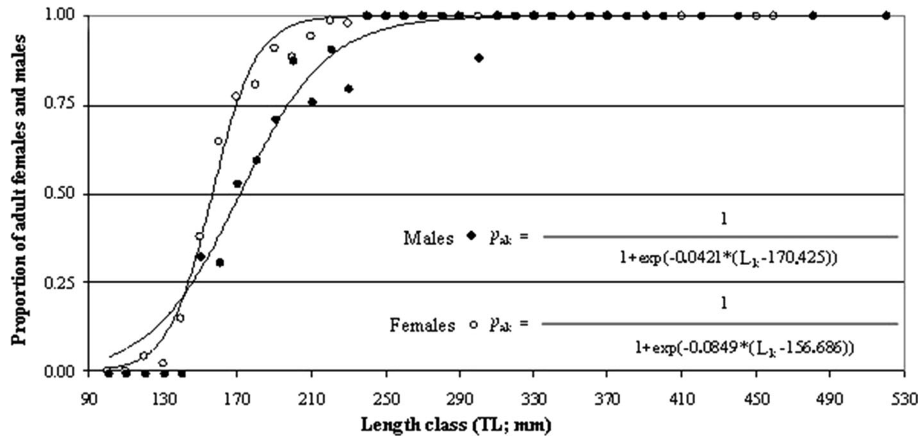

Fig. 6 Overall (years combined) proportions of mature specimens by size class for *P. erythrinus* males and females with logistic fits and corresponding estimated coefficients. *Solid* and *empty dots* denote males and females, respectively

Table 5 Length–weight relationship of *P. erythrinus* in the southern Tyrrhenian Sea

	N	TL range (mm)	*a*	*b*	SE (*b*)	R^2	*t* test	ANCOVA
Females	257	120–295	0.016	2.901	0.031	0.674	**	**
Males	47	130–320	0.013	2.965	0.055	0.684	ns	
All samples	304	120–320	0.016	2.905	0.027	0.676	**	

N number of specimens, *TL* total length; *a* intercept, *b* slope (allometry coefficient), *SE* standard error, R^2 determination coefficient, *t test* probability of Student's *t* test for isometry (H_0: $b = 3$), *ANCOVA* analysis of covariance for sex-related differences; significance level: *ns* not significant, ** <0.01

Discussion

The results support previous reports on the distribution pattern of the Mediterranean populations of *P. erythrinus*: the species is abundant between 10 and 100 m and occasional between 100 and 200 m (Santos et al. 1995; Spedicato et al. 2002). *P. erythrinus* is an important component of the upper shelf fish assemblage in the western Mediterranean Sea (Biagi et al. 2002; Gaertner et al. 2005) and specifically also in the southern Tyrrhenian Sea where the species is typical of the demersal fish community as deep as 100 m (Busalacchi et al. 2010).

Evidences of a differential distribution of fishing effort in the study area have been reported recently. The ground from Cape San Vito to Cape Gallo is characterized by high values of fishing intensity, compared with medium values in the central area from Cape Gallo to Cape Calavà and lowest values in the eastern area from Cape Calavà to Cape Suvero (Mangano et al. 2013, 2014).

The presence of density hot spots in the Patti and Castellammare Gulfs is related with the trawl ban for these areas. The highest values of persistence are reported for the Gulf of Patti, where protection measures are more extended in terms of surface and bathymetric range (from 10 to 500 m depth) than in the Gulf of Castellammare (200 m). Moreover, the common pandora has a depth distribution, which is completely located within the banned area.

Pagellus erythrinus is one of the species directly influenced by the presence of reserve areas: Stelzenmüller et al. (2007) reported that both catch per unit effort (CPUE) and length of the common pandora increased near to the Medes Islands Integral Reserve in Spain (north-western Mediterranean).

After the ban (1990), a fivefold and a twofold biomass increase have been reported for the common pandora in the Gulfs of Castellammare and Patti, respectively (Pipitone et al. 2000; Rinelli et al. 2004; Potoschi et al. 2006). Our results confirm the positive effect of protective measures on the abundance of the common pandora in the two Fishery Exclusion Zones. The presence of hot spots in the areas immediately adjacent to the "no take areas" may result from spillover due to the species' moderate mobility (Stelzenmüller et al. 2007).

The sex ratio was unbalanced in favour of females, which is in accordance with the results reported for Mediterranean and Atlantic populations (Vassilopoulou et al. 1986; Pajuelo and Lorenzo 1998). The presence of small-sized males (primary males) and large females in our samples suggests that sex change does not occur in each individual.

The low incidence of non-functional intersex in our samples may be correlated with several factors. First of all, sex identification was based only on macroscopic gonad examination. Consequently, the relative percentage of transitional individuals may be underestimated as gonads

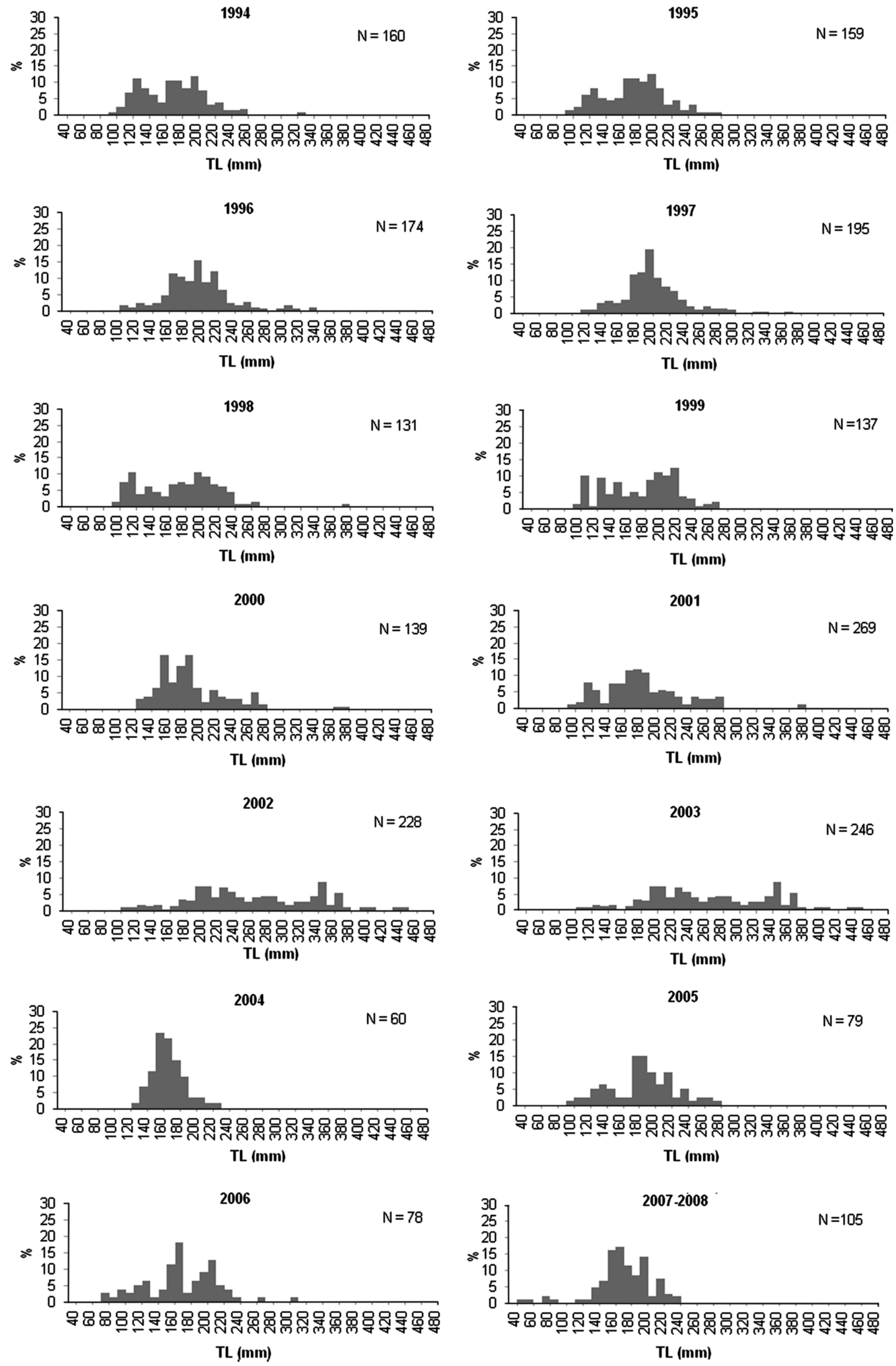

Fig. 7 Length frequency distributions of *P. erythrinus* by survey; class width 10 mm

have not been analysed histologically. Moreover, our samplings have been carried out with an annual periodicity. In the Mediterranean Sea, the common pandora generally spawns in spring/summer (Tsikliras et al. 2010), a second spawning period in autumn has been reported by some authors (Dieuzeide et al. 1955; Ghorbel and Ktari 1982; Vassilopoulou and Papaconstantinou 1990). Discordant opinions regard the time of sex reversal: it has been reported to occur during the prespawning, spawning or postspawning season in different studies (D'Ancona 1949; Larrañeta 1953; Zei and Zupanovio 1961). Therefore, the low number of transitional hermaphroditic stage may be due to the short sampling period.

Finally, a high degree of variability related to sexual differentiation within the species (protogynous hermaphroditism ranging from 9 to 100 %) has been reported by several authors (D'Ancona 1949; Larrañeta 1964; Ghorbel and Ktari 1982; Valdés et al. 2004) as well as an high

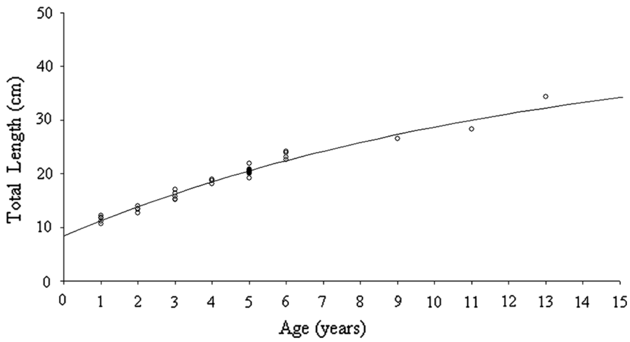

Fig. 8 von Bertalanffy growth curve for *P. erythrinus*

Table 6 Parameters of the von Bertalanffy growth function for *P. erythrinus* in different areas

L_∞ (mm)	*K*/year	$-t_0$	Φ'	Area	References
300	0.20	na	2.25	Sea of Cyprus	Livadas (1989)
401	0.17	0.75	2.44	South Levant Sea	El-Haweet et al. (2011)
334	0.37	0.23	2.62	South Levant Sea	Mehanna (2011)
240	0.16	2.60	1.96	Edremit Bay	Hoşsucu and Çakır (2003)
357	0.10	2.37	2.10	Gülbahçe Bay	Tosunoğlu et al. (1997)
482	0.06	na	2.14	Aegean Sea	Mytilenou (1989)
278	0.32	0.74	2.40	Cretan Shelf	Somarakis and Machias (2002)
326	0.18	na	2.28	Off Western Greece	Papaconstantinou et al. (1988)
379	0.20	na	2.46	Adriatic Sea	Juckic and Piccinetti (1981)
367	0.16	1.24	2.33	Sicilian Channel	Andaloro and Giarritta (1985)
400	0.18	1.00	2.45	Sicilian Channel	Fiorentino et al. (2012)
454	0.08	2.57	2.22	Southern Tyrrhenian Sea	Present study
543	0.12	1.12	2.54	Northern Tyrrhenian Sea	Abella et al. (2010)
345	0.33	*na*	2.59	Gulf of Lyon	Girardin and Quignard (1985)
517	0.14	1.12	2.57	Balearic Sea	Larrañeta (1967)
471	0.08	4.42	2.25	Off South Portugal	Erzini et al. (2001)
418	0.20	0.55	2.54	Off Canary Islands	Pajuelo and Lorenzo (1998)

L_∞ theoretical maximum (asymptotic) total length; *K* growth coefficient; $-t_0$ theoretical age at zero length; Φ' growth performance index; na not available

incidence of gonochorism (Larrañeta 1964; Ghorbel and Ktari 1982; Valdés et al. 2004).

The L_m values reported in this study (157 mm for females and 170 mm for males) are intermediate between those obtained by other authors, ranging from 113 to 180 mm for females and from 151 to 232 mm for males (Hashem and Gassim 1981; Santos et al. 1995; Pajuelo and Lorenzo 1998; Metín et al. 2011). The minimum size regulation of 150 mm TL adopted within the European Union Common Fisheries Policy (EU Regulation 1967/2006) for the common pandora is of limited benefit, because this value almost corresponds to the length at first maturity of females and is even smaller than the length at first maturity of males.

The length–weight relationship of *P. erythrinus* (sexes combined) shows a negative allometry, which is in accordance with results of previous studies (Hashem and Gassim 1981; Livadas 1989; Santos et al. 1995; Moutopoulos and Stergiou 2002; Hoşsucu and Çakır 2003; Metín et al. 2011; Fiorentino et al. 2012). Moreover, males show a higher allometry coefficient than females. Similar results have been reported by Pajuelo and Lorenzo (1998) for the Atlantic waters. However, females with a higher allometry coefficient than males have also been reported (Metín et al. 2011).

The asymptotic length (L_∞) was determined as 454 mm TL, which is close to the size of the largest fish examined (480 TL male). The growth coefficient value ($k = 0.08$ year^{-1}) indicates that growth was lower than reported by other authors except for Mytilineou (1989). The growth performance index ($\Phi' = 2.22$) falls between the estimates reported for different Mediterranean areas (1.96–2.62) and is similar to the estimates reported for the eastern Atlantic (2.25–2.54) (Table 6). No geographical trend was detectable.

Considering the over-exploitation status of almost all Mediterranean demersal resources (Leonart and Maynou 2003), our results support the general idea that the protective measures as FEZ (Fisheries Exclusion Zone) can contribute to enhance fish stocks. This is essential especially in an area such as the southern Tyrrhenian Sea, which is characterized by a high level of exploitation (Mangano et al. 2013, 2014).

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