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Distribution and population structure of the *Chlorophthalmus agassizi* (Bonaparte, 1840) on an unexploited fishing ground in the Greek Ionian Sea

By A. Anastasopoulou[1], C. Yiannopoulos[2], P. Megalofonou[2] and C. Papaconstantinou[1]

[1]*Hellenic Centre for Marine Research, Institute of Marine Biological Research, Athens Sounio, Mavro Lithari, Anavissos Attica;*
[2]*Department of Zoology, Marine Biology, University of Athens, Panepistimiopolis, Athens, Greece*

Summary

The distribution and population structure of the shortnose green eye, *Chlorophthalmus agassizi*, were studied in the Greek Ionian Sea using data collected during experimental trawl surveys carried out from December 1996 to November 1997. The length–frequency distribution ranged between 45 and 201 mm total length (TL). The significant increase in average size linked with depth has been observed, supporting the general 'bigger-deeper' phenomenon. Specifically, 1528 individuals were measured in the 300–400 m depth zone with a mean TL = 101 mm, 2351 individuals in the 400–500 m depth zone with a mean TL = 132 mm and 1889 individuals in the 500–600 depth zone with a mean TL = 145 mm. Age and growth of the population were determined by otolith readings. Twelve age groups were identified. The von Bertalanffy growth function (VBGF) parameters were $L_\infty = 202.22$ mm, $K = 0.20$ and $t_o = -1.6$ years. Natural mortality was estimated at 0.285 per year, while total mortality was estimated at 0.65. The reproductive period of *C. agassizi* extends from spring to autumn, with greater activity in the summer.

Introduction

Shortnose greeneye, *Chlorophthalmus agassizi* (Bonaparte, 1840), is a demersal fish species living on the continental shelf and upper slope over mud and clay bottoms. Depth distribution ranges from 50 to 1000 m, while catch data indicates a schooling habit. The species ranges from Spain to Senegal in the eastern Atlantic and is very abundant in the central basin of the Mediterranean (Whitehead et al., 1986). The shortnose greeneye has been reported in Greek seas by various authors (Taaning, 1918; Kaspiris, 1973), while Economidis (1973) and Papaconstantinou (1988) summarized its presence in Greek waters. The species is very abundant in the Ionian Sea (Anonymous, 1999; D'Onghia et al., 2003; Politou et al., 2003), especially in the 300–600 m depth zone, whereas no individuals were caught below 700 m. Distribution and abundance data analyses in the Greek Ionian Sea show that the entire area is characterized by the high presence of *C. agassizi* as the dominant species, indicating a low exploitation level in the area (Anonymous, 2003; D'Onghia et al., 2003; Politou et al., 2003).

The commercial fishery in Greece is mainly carried out to depths of 500 m; extended fishery in deeper waters remains unexploited. The biology and ecology of the species in the deep waters of Greek seas represent a new research field for marine and fisheries biologists in the area. In recent years several research projects focused on the deep fishery along the western coast of Greece (Mytilineou and Politou, 1997; Petrakis and Papaconstantinou, 1998; Anonymous, 1999). These projects provided data on the biology of the species living at these depths (e.g. age, growth, length distribution, reproduction, diets, etc.), as well as information on their community structure in order to enrich knowledge of the deep-water ecosystem in the area.

Although the shortnose green eye plays an important role in the Mediterranean deep-sea fish assemblages (D'Onghia et al., 2003), no information is available on the size composition, depth distribution, growth, reproduction and mortality rates of the species in the Greek Ionian Sea. The aim of this study was to identify the distribution and growth of *C. agassizi* in the Ionian Sea. This information will be used for local resource management, and will provide a benchmark to estimate the effects of fishing on this still unexploited population.

Materials and methods

A total of 121 318 specimens was collected by the commercial trawler 'Panagia Faneromeni II' (26 m length, 450 HP) using a net with a cod-end mesh size of 14 mm from knot to knot. Sampling took place along the south coast of the Greek Ionian Sea (Fig. 1) on a monthly basis from December 1996 to November 1997. The sampling area covered about 1500 km^2 suitable for bottom trawling. Sampling was carried out at depths of 300–800 m (92 stations) during daylight hours (07.00 and 19.00 hours). The shortnose green eye was found at 61 of the 92 stations in waters deeper than 340 m. A random depth-stratified sampling strategy was employed, with stations positioned either deeper or shallower than 500 m. Duration of the hauls was 30–100 min, and trawling speed was around 2.5 knots. The number and weight of the catches were standardized to 1 h of haul, allowing for comparative results.

Specimens were measured while fresh or defrosted, recording total length (TL) to the nearest millimetre and weight (W) to the nearest 0.1 g. Otoliths were removed and stored dry for further examination. The maximum length of otoliths (L_o) was measured to the nearest 0.1 mm and weighed (W_o) to the nearest 0.001 g. Sagital otoliths were immersed in a mixture of 30% alcohol and 70% glycerine in a black dish for about 30 min, and a reading was achieved by compound stereoscope using reflected light. Otoliths of 2092 specimens were examined. The marginal growth increment distances to the core were analysed to determine the timing of growth check formation. The age–length key was derived from the assumed annual

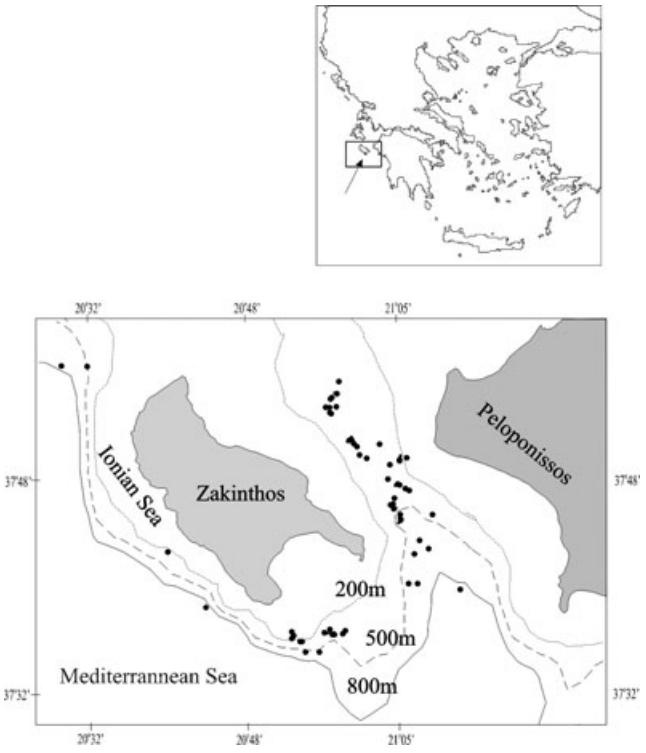

Fig. 1. Map of the study area in the Greek Ionian Sea. Upper right corner drawing represents the Greek Ionian Sea; arrow shows sampling area. Main drawing represents sampling area indicating isobaths (200 m, 500 m, 800 m) and sampling stations (dots •). Fishing was carried out at depths from 300 to 800 m

periodicity of otolith growth rings. The back-calculation age analysis was made using the linear relationship between TL and otolith radius (R). Otolith radius was expressed in mm, and defined by the linear distance from the centre of the nucleus to the edge of the otolith in the post-rostrum area. The best relationship fitting the pooled data were chosen on the basis of the highest R-squared value.

Based on the depth distribution of the species and our data, the study area was divided into three zones: 300–400, 400–500 and 500–600 m for assessment of the depth : length relationship. *Chlorophthalmus agassizi* were found in depth zones >600 in only two stations. At a depth of 606 m, 283 individuals were found; this station was added to the 500–600 m depth zone. At 665 m depth, only four individuals were found and thus they were not used in the calculations. To test the null hypothesis that fish size is depth-independent, a linear regression analysis for the variables of size and depth was performed. To test the null hypothesis that the TL medians of each depth zone are the same, the non-parametric Kruskal–Wallis test was adopted.

Morphometric correlation relationships between TL, standard length (SL) and otolith length (Lo) were calculated applying linear regression (Labropoulou and Papaconstantinou, 2000), while those between TL, weight (W), otolith length (Lo) and otolith weight (Wo) were calculated applying exponential regressions. To test for isometry, the allometric index values obtained were compared with the expected values using Student's t-test (Sokal and Rohlf, 1981).

Length–weight relationships were based on the regression $W = aL^b$, where W = weight in g, TL = total length in mm; a = constant; b = slope or allometric parameter. *Chlorophthalmus agassizi* is a synchronous hermaphroditic species (Mead et al., 1964; Sulak, 1977; Whitehead et al., 1986), thus all analyses were carried out for the entire population. Size–frequency distributions for the entire population were performed each month from December 1996 to November 1997.

The relationship between TL and age was modelled using the von Bertalanffy growth function (VBGF). Estimation of the growth parameters L_∞ (asymptotic total length in mm), k (curvature parameter of VBGF in mm^{-1}) and t_o (age at length zero in years), were based on the overall size distribution of both sexes using the Marquardt algorithm for non-linear least-squares parameter estimation (STATGRAPHICS program) from the lengths at age obtained from direct otolith readings. The growth performance index φ' (Pauly and Munro, 1984) in the study area was estimated using the equation $\varphi' = \log_{10}k + \log_{10}L_\infty$.

Total mortality (Z) was calculated from the length-converted catch curve (Pauly, 1983), while the natural mortality (M) was calculated using the model of Gunderson and Dygert (1988). Finally, the exploitation rate (E) was calculated according to the formula $E = F/(F + M)$, where F and M are the fishing and natural mortality respectively (Beverton and Holt, 1957).

The reproductive period of 433 specimens was estimated using the maturity stages of the gonads throughout the year. For histological preparation, the gonads were fixed in neutral 10% formaldehyde, dehydrated in increasing ethanol concentrations, clarified in Xylol and embedded in paraffin wax. Sections (5–7 μm thick) were stained with Mayer's haematoxylin and eosin. The maturity stage of male components was never determined macroscopically, therefore the classification of both components (female and male) in maturity stages was based only on histological criteria. Oocyte development stages were identified according to the Mayer et al. (1988) classification (I = immature, II = resting/recovery, III = early developing, IV = late developing, V = maturing, VI = spawning and VII = spent). The male component was based on the Buxton (1990) classification, with the difference that one more stage was added after the Buxton stage II (I = inactive, II = developing, III = pre-spawning, IV = spawning and V = spent). Analysis of the reproductive period for the two components took place separately.

Results

Size–frequency distributions

A total of 121 318 shortnose green eyes were caught in the study area from December 1996 to November 1997. The annual length distribution obtained from monthly sampling showed a range from 45 to 201 mm, with a dominant mode between 85 and 130 mm. Monthly length–frequency distributions are given in Fig. 2. Statistically significant differences between the mean TL among the months were found (ANOVA test: $F = 68.04$, $P < 0.05$).

Individuals with TL <60 mm showed a poor presence throughout the year. Fishing recruitment takes place from mid-autumn to mid-winter, with a modal mean length from 43 to 69 mm (mean 53 mm). Because the reproductive period for the species is so extensive (mainly from May to September), with a peak in summer, these individuals should have been born at the beginning of the reproductive period of the same year, but they were only 5–7 months old. These individuals were found in March with a mean length of 63.4 mm, 2 months later (in May) with a mean length of 70.1 mm and with a mean length of 73 mm in July. From August to November their monthly grow was 1.5–2.0 mm. The fishing recruits of 53 mm mean length grew to a mean size of 84 mm

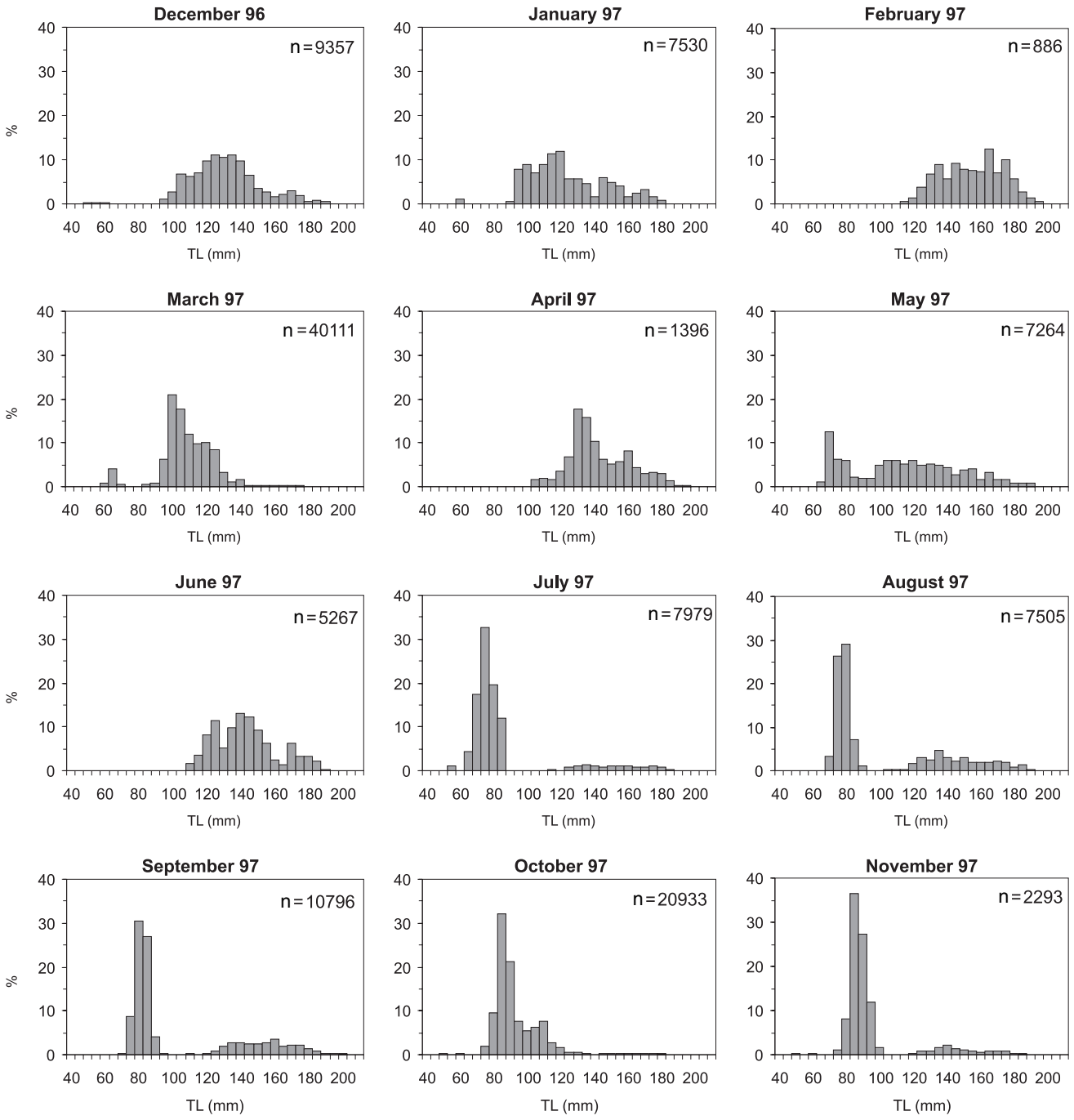

Fig. 2. Relative (%) size distribution (TL in mm) of *Chlorophthalmus agassizi* in relation to time (monthly samples December 1996–November 1997, n = 121 318 individuals) in Greek Ionian Sea

in a year. In October, when the rings were completely formed, individuals were 13–17 months of age.

Size and abundance distribution by depth

The species was found in depths between 300 and 700 m in the study area. The regression analysis of the TL (mm) in relation to the depth (D, m) showed a statistically significant relationship between them at the 99% confidence level. The equation obtained was: TL = 17.8677 + 0.242413*D, $r = 0.60$, n = 5768. Hence, there is a tendency of the mean size to increase with depth. According to Kruskal–Wallis test there is a particularly significant difference ($P < 0.05$) between the size of fish and depth, indicating that smaller individuals are in the shallower zone and that larger fish prefer deeper waters (Fig. 3). Measured were 1528 individuals with 101 mm mean TL (SE = 0.62) at 300–400 m, 2351 with 132 mm mean TL (SE = 0.64) at 400–500 m and 1889 individuals with 145 mm mean TL (SE = 0.49) at 500–600 m. All fishing recruits appeared in the first depth zone (Anastasopoulou, 2005).

Estimation of growth parameters

Age of shortnose green eye was based on otolith readings. All otoliths showed the ring pattern common to teleost fishes, with opaque and hyaline rings laid down around an opaque nucleus, these being attributed to fast and slow growth patterns (Williams and Bedford, 1974).

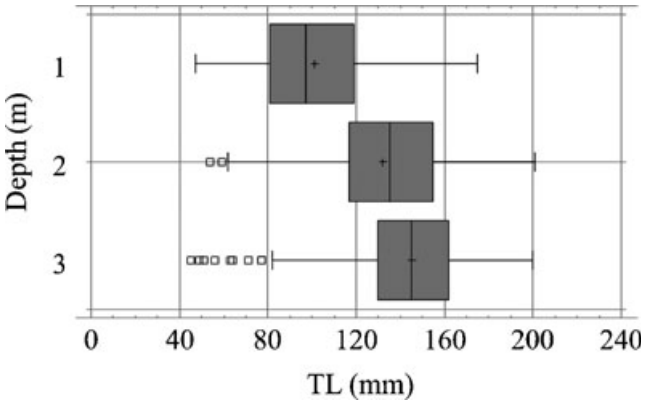

Fig. 3. Box plot of *Chlorophthalmus agassizi* (TL, mm) in relation to depth zone (1 = 300–400 m, 2 = 400–500 m, 3 = 500–600 m)

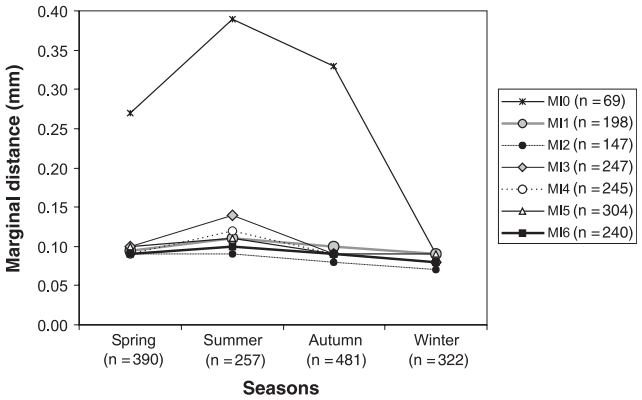

Fig. 4. Marginal increment analysis (MI, mm) for first five annual rings including 0-ring (MI0 = marginal increment for 0 or demersal ring, MI1–MI6 = marginal increment for first to sixth ring; marginal distance = mean value of each r_{adius}-ri ring of 1210 otoliths)

The incidence of opaque and hyaline material at the margin of the otolith in a year-period indicates some degree of periodicity in the ring formation. The nucleus showed false rings close to the core; the first complete hyaline zone surrounding the opaque central nucleus was always distinct and interpreted as a 'transitional zone', indicating a change of habitat from a pelagic larval phase to the demersal juvenile phase. Among the smaller specimens (48–49 mm TL) caught in December, few appeared to have the first hyaline 'demersal' ring; these specimens (aged 0+) were born the previous summer.

Marginal increment analysis. The study of seasonal marginal increment distance for the first six rings from the centre of the nucleus illustrated that the lowest values for all rings (including the demersal ring) took place at the beginning of winter while the highest took place during the summer, which proves that from summer to winter all annual rings have been formed (Fig. 4).

Table 1.
Age–length key for *Chlorophthalmus. agassizi* captured in the Ionian Sea between December 1996 and November 1997

	AGES													
Length Class (mm)	0	1	2	3	4	5	6	7	8	9	10	11	12	N
36–40														0
41–45														0
46–50	7													7
51–55	6													6
56–60	16													16
61–65	9													9
66–70	20	3												23
71–75	15	51												66
76–80		94												94
81–85		73												73
86–90		47	1											48
91–95		46	7											53
96–100		18	40											58
101–105		7	40	4										51
106–110			53	7										60
111–115			46	17										63
116–120			27	43	3									73
121–125			22	52	10									84
126–130				63	34	2								99
131–135				32	74	5								111
136–140					87	20	1							108
141–145					53	41	1	1						96
146–150					54	64	14	1						133
151–155					15	77	29	5	1					127
156–160					3	43	29	18	3	2				98
161–165						21	39	45	14	2				121
166–170						5	19	67	22	3	4			120
171–175								79	19	4	8		1	111
176–180								38	36	9	10	1	1	95
181–185								1	27	9	13	5	2	57
186–190									6	3	7	7	2	25
191–195										1	2	1		4
195–200													1	1
201–205													1	1
N	73	339	236	218	333	278	132	254	129	32	44	14	8	2090
X.	63.0	83.1	108.7	123.4	138.6	150.6	158.6	169.2	174.8	178.0	180.0	185.8	186.6	
SD	7.5	7.5	8	6.9	7.6	7.4	6.4	6.3	7.6	7.7	6.4	3.4	9.7	

Age–length key, age distributions and back-calculation. On the assumption that the rings were laid down annually after the first year, the maximum age estimated was 12 years. The age–length key obtained from 2090 otoliths is presented in Table 1. The length overlap between age classes increased with age. Age groups 4–10 especially overlapped by 30 mm.

According to the age–length key and the length distribution, the number of individuals in each age group was calculated (Fig. 5) for the entire study period and for each month separately (Fig. 6). The majority of the population studied ranged from age 1 (juveniles) to age 5 (adults). Ages from 10 to 12 years were only 0.84% of the population.

The back-calculated lengths (Table 2) were estimated by the equation:

$$TL = -47.9237 + 99.2026 * R$$

The most rapid growth occurred in the first year of life and was 40.1% of the entire growth. After the first year there was a decrease in annual growth, while a relatively steady annual growth (≅5.5–5%) occurred from the 6th to the 8th year. Beyond the 8th year, there was a decreasing growth rate according to age. From Table 2 it must been noted that the mean back-calculated length of each age group was smaller from the correspondingly observed length at the time of fishing, except ages 9+ where the inverse phenomenon was apparent. Consequently, the mean observed lengths at the time of fishing were smaller than the back-calculated mean lengths of the next age-class.

von Bertalanffy model Parameters of the von Bertalanffy growth equation L_∞, k, t_o and W_∞ were estimated for all individuals. Computation of the von Bertalanffy growth parameters using the observed ages gave the following results:

Parameters	Estimate	Standard Error
L_∞	202.22	1.30
K	0.20	0.004
t_0	−1.6	0.03

The growth performance index (φ') of 3.92 was calculated using these parameters. The longevity of 14.7 years was estimated using the *K*-value.

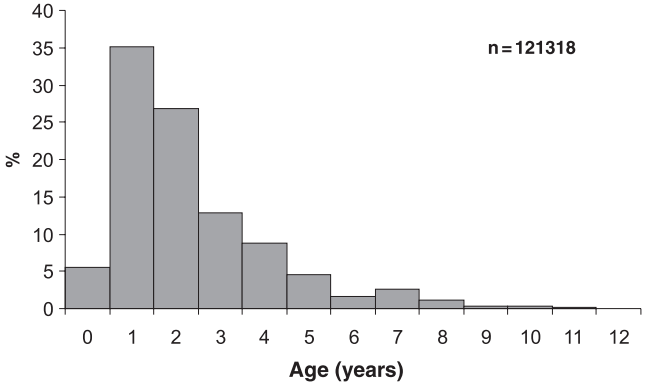

Fig. 5. Relative (%) age distribution of *Chlorophthalmus agassizi* captured in study area

Morphometric relationships. Morphometric relationships between TL–SL, TL–*W*, L_o–TL, L_o–W_o and TL–*R* are summarized in Table 3. Analysis of variance indicated significant relationships between the two parameters ($P < 0.01$) for each equation. For both relationships (SL–TL; W_o–L_o) the slope (b) of the regressions indicated an isometric growth. For the relationships (*W*–TL; TL–*R*; TL–L_o) the slope of the regressions indicated positive allometric growth, while negative allometric growth was indicated for L_o–TL.

Size–weight relationship. During the course of the survey 4200 specimens were weighed and used to calculate the relationship between TL (mm) and weight (*W*, g). The equation of the relationship is:

$$W = 0.0000026 \times L^{3,17}, r^2 = 0.98, n = 4200$$

The relationship between these two parameters was statistically significant (ANOVA, $F = 192814.92$, $P < 0.01$) and indicated positive allometry.

Mortality

The results of total mortality (*Z*) calculated from the length-converted catch curve (Pauly, 1983) was estimated to be 0.65 ($r^2 = 0.985$), while the natural mortality (*M*) calculated by the Gunderson and Dygert (1988) method was 0.285. Fishing mortality (*F*) was calculated as 0.365. The exploitation rate was 0.56. In the study area fishing pressure took place only to depths of 400 m. Deeper waters must be considered as unexploited.

Reproduction

In all samples the histological study revealed the presence of ovotestis in which both female and male tissues occurred contemporaneously and clearly separated into two zones by the connective tissue.

The percentage of the different gonad stages over the study period, as shown in Fig. 7 (female component) and Fig. 8 (male component), indicated an extended reproductive period from May to September.

The following findings were observed particularly for the female component. Immature or inactive females (Stages I and II) were found throughout the year, while higher proportions were observed from November (64%) to February (51%). February and March is the period in which the secondary growth phase begins (Stage III in high percentages). Stage V (appearance of vitellogenic oocytes) was of short standing, with low proportions. Spawning females (Stage VI) appeared for the first time in April (6%), but higher proportions were observed during May–September with a peak (70%) in August. Only a few individuals (5%) were found to spawn in October. Spent stage (VII) females were found during all reproductive periods up to December. The highest proportion of spent stage females occurred in October.

Inactive males (Stages I and II) were found throughout the year, but with a higher proportion in December (79%). Pre-spawning males (Stage III) appeared mainly from February (27%) to April (62%). Spawning males (Stage IV) appeared from April (9%) to November (10%), with a peak (78%) in August. Spent males were found from May (3%) to February (5%), with higher proportions from October (58%) to January (50%).

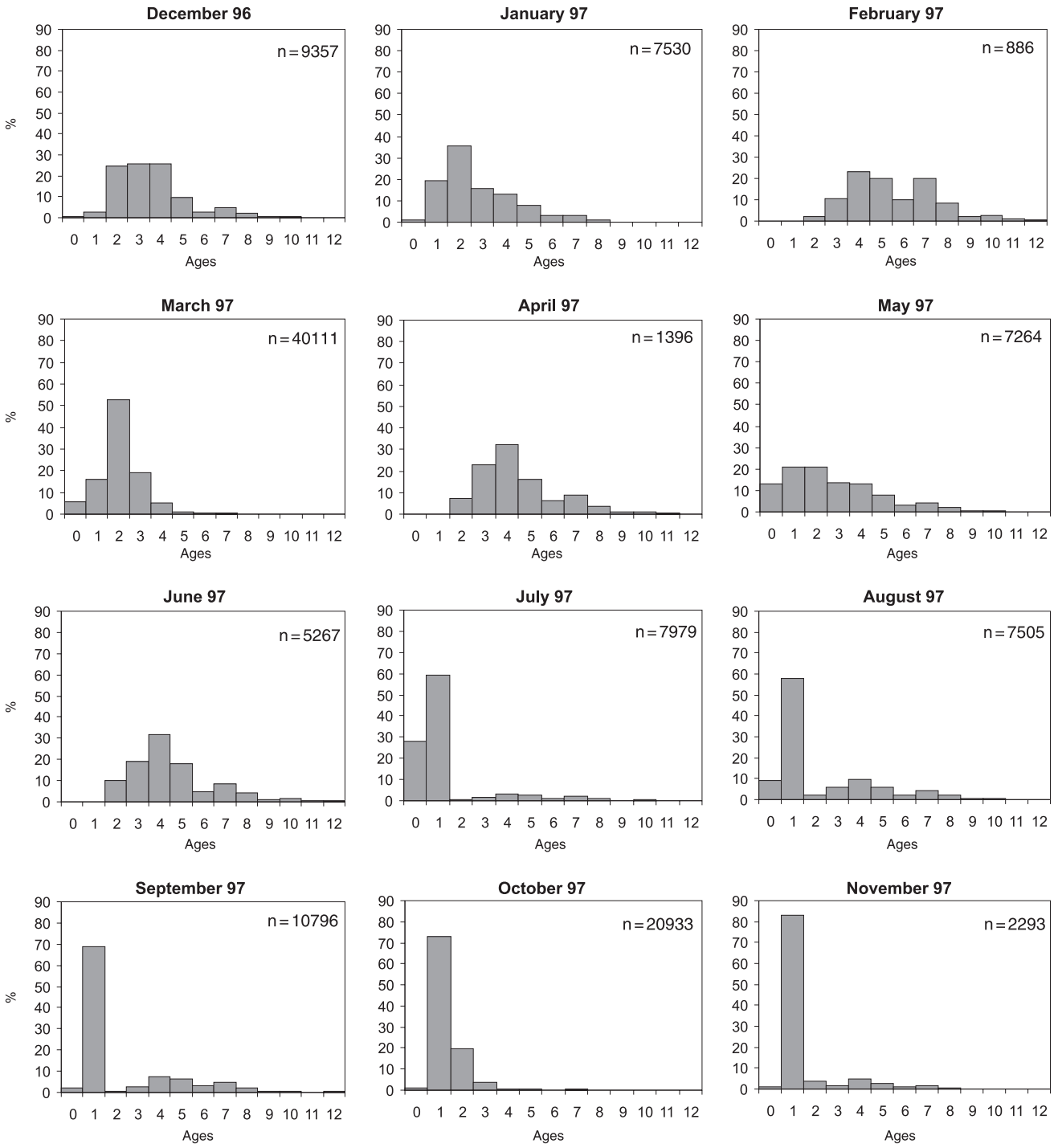

Fig. 6. Relative (%) age distribution of *Chlorophthalmus agassizi* relative to time (monthly samples December 1996–November 1997, n = 121 318 individuals) in the Greek Ionian Sea

Discussion

Chlorophthalmus agassizi fishing recruits ca. 45–55 mm TL in the Ionian Sea occurred mainly in the shallower depth zone (300–400 m) from mid-autumn to winter; this was about 4–5 months after the beginning of spawning (April–May). Within 1 year they had reached a mean size of about 85 mm TL. The modal component of the recruits was generally well separated from the others. However, progress of cohorts over time (especially from the third age class) was difficult to distinguish in the length frequencies; this might be due to length overlapping in the size age classes and to the extensive reproductive period that gives rise to a succession of larval cohorts. For this reason age distributions were obtained from otolith readings.

The bathymetric trend in the above area indicates a size-related depth distribution pattern known as the 'bigger-deeper' phenomenon (MacPherson and Duarte, 1991), shown in many deep-sea species inhabiting the upper slope (Massuti et al., 1995; Moranta et al., 2004). However, the 'bigger-deeper' phenomenon is not a general rule for the entire demersal deep sea fishes because a 'smaller-deeper' trend has also been observed for the middle and lower slopes (Stefanescu et al., 1992; Moranta et al., 2004). Size increases in *C. agassizi* according to observed depths in all seasons in the Ionian Sea

Table 2
Back-calculation of *Chlorophthalmus agassizi* in the Ionian Sea

			AGES											
t	N	MOL	1	2	3	4	5	6	7	8	9	10	11	12
0	73	63												
1	339	83.13	81.68											
2	236	108.7	76.33	101.93										
3	218	123.43	76	101.98	118.8									
4	333	138.55	76.61	102.66	118.31	132.32								
5	278	150.64	74.72	98.11	113.72	127.58	140.81							
6	132	158.56	75.71	99.42	114.76	128	140.02	150.55						
7	254	169.21	75.55	97.81	112.33	125.6	137.852	149.05	158.81					
8	129	174.76	75.27	99.72	114.34	128.11	140.69	152.57	162.38	169.81				
9	32	178	74.42	98.66	113.83	127.39	140.08	150.01	161.45	169.08	174.99			
10	44	180	74.54	99.87	114.77	128.51	141.18	153.06	162.72	170.41	176.4	181.11		
11	14	185.8	72.87	98.07	112.91	126.86	139.68	152.28	162.48	170.18	176.86	181.59	186.32	
12	8	186.62	76.86	102.06	117.02	130.8	143.19	155.6	165.05	172.71	179.54	184.62	189.2	191.31
MBCL			76.72	100.31	115.5	128.6	139.83	150.71	160.5	169.95	176.25	181.64	187.37	191.31
SD			6.82	7.5	8.05	8.42	7.82	7.93	7.79	7.33	7.01	7.31	6.92	2.78
N	2090		2018	1679	1443	1225	892	614	482	227	99	66	22	8
YLG			76.72	23.59	15.19	13.1	11.23	10.88	9.79	9.45	6.3	5.39	5.73	3.94
YLG%			40.1	12.33	7.94	6.85	5.87	5.69	5.12	4.94	3.29	2.82	3	2.06

Table 3
Morphometric relationships for *Chlorophthalmus agassizi* from the Ionian Sea

Correlation	N	r^2
SL = 0.834496*TL	2307	0.999
$W = 0.0000026*TL^{3.17}$	4200	0.980
$L_o = 1.59873 + 0.0175085*TL$	2090	0.858
$TL = -59.4382 + 48.9911*L_o$	2090	0.858
$W_o = 0.00009*L_o^{2.96}$	570	0.950
$TL = -47.9237 + 99.2026*R$	2327	0.888

SL, standard length (mm); TL, total length (mm); W, total weight (g); L_o, otolith length (mm); W_o, otolith weight (g); N, number of specimens; r^2, correlation coefficient.

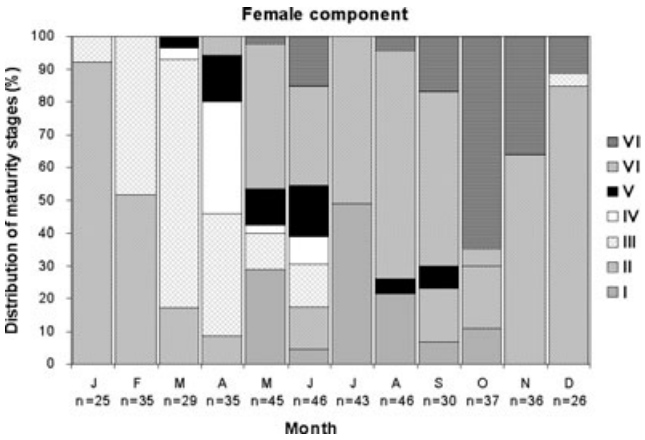

Fig. 7. Monthly distributions of maturity stages (I–VII) of *Chlorophthalmus agassizi* caught in the Ionian Sea for female component of the gonad

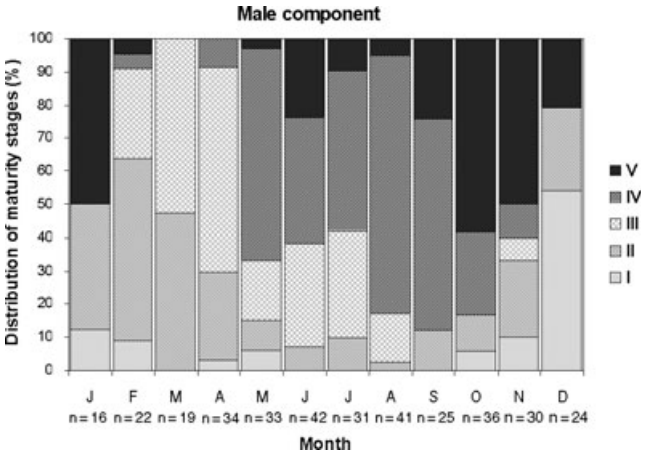

Fig. 8. Monthly distributions of maturity stages (I–V) of *Chlorophthalmus agassizi* caught in the Ionian Sea for male component of the gonad

were mostly due to the young-of-the-year and juveniles, which move towards deeper zones as they grow. Young shortnose green eye belonging to the 0-age group are pelagic, living in the upper layers of the water column (Taaning, 1918); between 25 and 44 mm TL they descend to deeper waters. The absence of specimens <45 mm from the present samples possibly corroborates the Taaning (1918) findings. In the same area, the strong relationship of TL and depth of *C. agassizi* was mentioned by Anonymous (2001, 2003), where all TL <110 mm individuals were found in the 300–500 m depth zone whilst bigger specimens were found at 500–700 m. Results similar to the present study have been noted for the northern part of the Greek Ionian Sea (D'Onghia et al., 2003; Politou et al., 2003), where *C. agassizi* is the dominant species at 300–500 m. These results are in agreement with the bathymetrical distribution (Fischer et al., 1987) from 50–1000 m, but the species is abundant to depth zones 350–450 m.

Growth ring formation has been reported for many deep-water fish (Morales-Nin, 1990; Bergstad, 1995; Morales-Nin et al., 1996).

In the present study, the pattern of monthly variation of otolith opaque and hyaline edges (covering a 1-year period) has confirmed the periodicity of incremental deposition, suggested the formation of one ring per year. This is evident from the seasonal marginal increment analysis. Marginal increment variation from samples covering a year period allowed us to determine the periodicity of the rings in order to prove their formation period and that they were laid down

yearly (Kerstan, 1985), thus helping to understand the causes of ring formation. Our results proved that the rings were very distinct in several age classes that they were formed from summer to winter (where the lowest values were observed), and that there was a very strong relationship between TL and radius (positive allometry). The very stable 'demersal ring' had completely formed when the fish was about 63 mm TL, indicating ontogenetic migration towards deep waters, as shown in many shelf and slope fish species (MacPherson and Duarte, 1991). These specimens hatched the previous summer and were up to 6 months of age. The next hyaline ring corresponded to 1 year of age. Taking 1 July as the birth date, the specimens at the beginning of the winter were, in fact, 16–18 months old.

Main factors in ring formations in deep-sea organisms are temperature cycles, spawning and changes in feeding pattern (Massuti et al., 1995 and references therein). In the Mediterranean, at depths below 150–200 m the water temperature is stable throughout the year (Salat and Font, 1987) and thus by extension plays no significant role in the periodicity of otolith ring formation. Moreover, as seasonal growth occurred even in immature individuals, and ring formation was completed at the beginning of the winter (after the spawning period), spawning was shown to be unrelated to ring formation. Seasonal fluctuations in feeding patterns, as shown in other deep-water species (Childress et al., 1980; Merret, 1987; Massuti et al., 1995), offer a more reasonable hypothesis to explain growth seasonality. Oligotrophic Mediterranean waters are affected by the two annual peaks of primary production, i.e. spring and autumn. This periodicity in the primary production rhythm has given rise to seasonal food availability, not only in surface waters, but also on the slope.

Twelve age-groups were determined from otolith readings of the collected fishes. The presence of many age-classes seems to be a common feature of all deep-sea fish populations (Rannou, 1976; Bergstad, 1995; Morales-Nin et al., 1996). Overlapping between successive age groups is obvious for species with extensive reproductive periods (Johnson et al., 1983; Stergiou, 1991). The proportion of ages 1 and 2 of the total (or monthly) population fished in the study area during the entire year was remarkably high (35% and 26%, respectively).

Growth of green eye from the Greek Ionian Sea was most rapid during the first year. As the estimated longevity is about 14–15 years, a satisfactory coverage of the sampled population age distribution was obtained. Growth parameters of *C. agassizi* are shown here for first time. Values of K and φ' (0.20 and 3.92, respectively) showed a high growth rate with a moderate longevity.

The results of morphometric relationships were similar to those obtained for many other teleost fish species. Generally, the sagitta size in relation to the fish growth showed a negative allometry. This observation has been studied in macrourids (Massuti et al., 1995; Labropoulou and Papaconstantinou, 2000) and *Bathypterois mediterraneus* (Morales-Nin et al., 1996), and has been reported as more pronounced in species found at greater depths. The L_o/TL and W_o/L_o relationship showed a goodness-of-fit with r^2 equal to 0.86 and 0.95, respectively, thus allowing fish growth patterns to be inferred from otolith dimensions.

The length–weight relationship was similar to that of fishes in the Balearic Islands (Merella et al., 1997), North Aegean (Filiz and Bilge, 2004) and western Mediterranean (Sabatini et al., 2003), indicated a strong positive allometry ($b = 3.178$, present study; $b = 3.28$, Balearic islands; $b = 3.37$, North Aegean; $b = 3.33$, western Mediterranean). In contrast, Diaz et al. (2000) estimated the regression coefficient for the same species in Colombian waters as $b = 2.82$, showing perhaps a negative allometry.

Methods for deriving estimates of M from catch data can be applied mainly to lightly exploited populations (Vetter, 1988). Any fishing pressure at these depths does not affect the study area >400 m, thus the exploitation rate must be considered as rather low.

Chlorophthalmus agassizi (as well as all Chlorophthalmidae species) is known as a simultaneous hermaphrodite (Mead et al., 1964), some of which are batch spawners (Merrett and Haedrich, 1997). The ovary was characterized as asynchronous by the contemporary presence of oocytes at progressive stages of development and was the most evident component of the ovotestis in all specimens; the testis appeared as a filament zone, the maturity stage of which was never discriminated macroscopically. In the female component, the contemporary presence of oocytes in different developmental stages in the ripe gonad, together with a very extensive reproductive period (April–October), would indicate that *C. agassizi* can spawn more than once during the reproductive period and thus can be considered as a batch spawner fish. In the male component, the reproductive period is more extensive (April–November) and thus self-fertilization could not be possible. Since it lives in large shoals, which suggests that meeting a sexual partner would not be difficult, cross-fertilization seems to be most probable hypothesis. This is also confirmed by the presence of a light organ in the perianal area, which could be used for sexual attraction (Follesa et al., 2004). The spawning peak for both female and male components was observed in August.

The extensive reproductive period of *C. agassizi* in the present study was found to be from April to October/November (only for the male component), with a peak in August, similar to that of the western Mediterranean Sea (Follesa et al., 2004) in which the reproductive period was from May to September with a peak in July.

Data from this still-unexploited study area are valuable for future comparisons with other areas or for future studies in the same area. A longer study period is required, however, to elucidate specific aspects associated with the biology and ecology of the species, validating at the same time the results of the present study.

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Author's address: Aikaterini Anastasopoulou, Hellenic Centre for Marine Research, Institute of Marine Resources, 47o Km Athens Sounio, Mavro Lithari, PO Box 712, GR-19013 Anavissos Attica, Greece.
E-mail: kanast@ncmr.gr