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Mediterranean Marine Science

Vol 10, No 1 (2009)

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doi: 10.12681/mms.122

To cite this article:

RAGONESE, S., NARDONE, G., OTTONELLO, D., GANCITANO, S., GIUSTO, G., & SINACORI, G. (2009). Distribution and biology of the Blackmouth catshark Galeus melastomus in the Strait of Sicily (Central Mediterranean Sea). *Mediterranean Marine Science*, *10*(1), 55–72. https://doi.org/10.12681/mms.122

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Mediterranean Marine Science
Volume 10/1, 2009, 55-72

Distribution and biology of the Blackmouth catshark *Galeus melastomus* in the Strait of Sicily (Central Mediterranean Sea)

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Abstract

*The Blackmouth catshark, Galeus melastomus, Rafinesque, 1810 (Carcharhiniformes; Scyliorhinidae), is a common, although at present discarded, by- catch of the bottom trawl fisheries in the Strait of Sicily. Given its ecological interest, data gathered in experimental bottom trawl surveys were analysed in order to describe its distribution and main biological traits. The Blackmouth catshark was sampled almost exclusively on the upper slope (200-800), showing the highest frequency of occurrence (69-100%), biomass (BI; 10-85 kg*km^{-2}) and density (DI; 54-506 N*km^{-2}) indexes in the deeper (501-800m) grounds. Individual size (total length, TL, mm) were between 70-590 and 90-510 in females and males, respectively. The sex ratio (S_R) was around 0.5. The S_R by size showed a gradual decrease till 450 mm class size, followed by an increase up 1 after 500 mm. Virginal/immature specimens represented the bulk of the samples in both females (77%) and males (65%); the length at 50% of sexual maturity ($L_{m50\%}$) and corresponding maturity range ($L_{m25\%}$ - $L_{m75\%}$) was 433 (423-443) and 380 (366-394) mm, respectively.*

Keywords: *Galeus melastomus;* Bottom trawl surveys; Distribution; Biological traits; Mediterranean Sea.

Introduction

The Blackmouth catshark, *Galeus melastomus,* Rafinesque, 1810, is a small demersal-benthic elasmobranch (sensu FRISK *et al.*, 2001) distributed in the eastern Atlantic and the Mediterranean Sea (COMPAGNO, 1984; RELINI *et al.*, 1999; FROESE & PAULY, 2008). Within the Mediterranean Sea, it is the main representative of the genus; the other valid (CASTILHO *et al.*, 2007) *Galeus species,* the Saw tail catshark, *Galeus atlanticus* (Vaillant, 1882), being limited to the Alboran Sea (BAINO *et al.*, 2001). In the Mediterranean Sea, the Blackmouth catshark occurs from the outer shelf edge (~ 150m) down to the boundaries between the middle (800-1400m) and lower (>1400m) slope bottoms, no matter the basin considered

(GOLANI, 1986/87; STEFANESCU *et al.*, 1992; RELINI *et al.*, 1999; BAINO *et al.*, 2001; JONES *et al.*, 2003; D'ONGHIA *et al.*, 2004; SION *et al.*, 2004; MORANTA *et al.*, 2004; REY *et al.*, 2005; CAPAPÉ *et al.*, 2008). However, it is worth remarking on , the occasional intrusions at 50-60m (Southern coasts of France; DELATTRE & MAIGRET, 1986; CAMPILLO, 1992) and the photographic (baited camera) identification (although not confirmed by capture) of *Galeus melastomus* specimens between 2300 and 3850m (Eastern Mediterranean; JONES in PRIEDE & BAGLEY, 2000).

The Blackmouth catshark is a multiple oviparous (IGLESIAS *et al.*, 2002) and the Mediterranean adult females carries within each oviduct from 1-2 up to 4 egg cases (TORTONESE, 1956; CAPAPÉ *et al.*, 2008), which are released over muddy bottoms (LO BIANCO, 1909, in TORTONESE, 1956, and CAPAPÉ & ZAOUALI, 1977). Although spawning occurs almost continuously (RELINI *et al.*, 1999; CAPAPÉ *et al.*, 2008), peaks were reported in late spring - summer (TORTONESE, 1956; RELINI-ORSI & WURTZ, 1975; CAPAPÉ & ZAOUALI, 1977; RELINI *et al.*, 1999). The species is an active nomadic generalist forager (RELINI-ORSI & WURTZ, 1975; MACPHERSON, 1980) with a wide niche breadth (MACPHERSON, 1981) and minimal variations in feeding habits by size and depth (CARRASSÓN *et al.*, 1992).

Information about length, sex and maturity-structures, considering the fishing divisions recognized by the General Fishery Commission for the Mediterranean Sea (PAPACOSTANTINOU & FARRUGIO, 2000; GFCM, 2001) are available for the Balearic (SION *et al.*, 2004; REY *et al.*, 2005), southern coasts of France (CAPAPÉ *et al.*, 2008), Sardinia (RELINI-ORSI &WURTZ, 1975; RINELLI *et al.*, 2005), the Ionian (CAPAPÉ & ZAOUALI, 1976, 1977; CAPAPÉ & BEN BRAHIM, 1984; TURSI et al, 1993; SION *et al.*, 2004), and the Adriatic (UNGARO *et al.*, 1997; 2001).

In the Strait of Sicily (the north-west side of the GFCM Ionian fishing division), *G. melastomus* is a common by-catch in the depth water red shrimp fisheries, although almost completely discarded at sea (GFCM, 1970; RAGONESE *et al.*, 2000; 2001), as is the general case for the species (CASTRO *et al.*, 1999; SCACCO *et al.*, 2002; CARBONELL *et al.*, 2003; SÁNCHEZ *et al.*, 2004; ABELLA & SERENA, 2005). No study exists on *G. melastomus* on the Italian side of the Strait of Sicily, and the objectives of the present study were to provide information about its abundance, length and sex composition, and reproductive biology.

Materials and Methods

Data about the Blackmouth catshark were gathered within the Mediterranean International Bottom Trawl Surveys (MEDITS) programme (ANON., 2007). In particular, the data were collected in spring-summer, between 1994 and 2007, inside the GFCM (2001) geographical subareas (GSA) 16 (Fig. 1); this area shows a slope shape extremely irregular, incised by many canyons, trenches and steep declines. The hydrological pattern (GRANCINI & MICHELATO, 1987; SARDÀ *et al.*, 2004a) is characterized by a basic three-layers horizontal stratification: the upper fresh Atlantic waters (AW, 0-200m, with temperature range of 15-22°C, according to the seasons), the intermediate salty Levantine waters (LIW, from ca. 200 m down to 500-700 m, with temperature range of 13-14°C) and

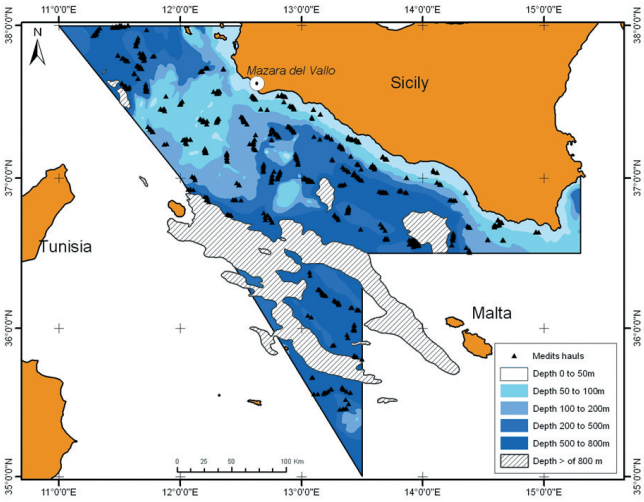

Fig. 1: The study area (Strait of Sicily according to the GFCM classification). Strata depth limits are represented with MEDITS haul locations overimposed.

the deeper transitional waters (DW, > 700 m; 12.8°C). Survey period and sample size (i.e. number of hauls), as well as information registered for the investigated species, changed according the administrative constraints; in particular, abundances were registered in all surveys (865 hauls; Table 1), whereas the biological data were collected between 1999-2007 surveys (664 hauls). Given the temporal shift, which might be a source of variability, a proper standard chronological time (0 < ST < 1, incremented by 1 for successive years) was assigned to each survey on the base of the days elapsed from 1st January to the median survey day divided by 365 days. Sampling was conducted with the same vessel (Sant'Anna; 32.2 m length overall; powered with a 736-kW engine) and the purpose-built bottom trawl GOC 73 net (2.4–2.9 m vertical opening of the mouth; 20mm-diamond stretched mesh size in the cod-end; FIORENTINI *et al.*, 1999; ANON., 2007). Daylight (30 minutes after dawn and before dusk) hauls, lasting 0.5 h and 1 h for shelf and upper slope bottoms, respectively, were realized according a depth-stratified sampling design. In particular, five depth strata (limits in meter, area in km^2) were identified: 10–50, 2979 (code A), 51–100, 5943 (B), 101–200, 5565 (C), 201–500, 6972 (D), and 501–800, 9927 (E). The sampling hauls were randomly allocated within the strata according to an area-proportional criterion. In 1999-2007 surveys, the bottom seawater temperature (BST; °C) was also registered in each haul by applying to the gear a minilog device (VEMCO, 2005), and elaborated by applying an *ad hoc* developed software.

The gross haul catch, once on the deck, was sorted for the Blackmouth catshark and overall abundance in weight and number recorded on board. The mean density (D_1; N*km^{-2}) and biomass (B_I; kg*km^{-2}) indexes, and the corresponding standard deviation and coefficient of variation (C.V.%), were estimated (for each stratum, shelf and

Table 1
Synopsys of the MEDITS surveys carried on from 1994 to 2007 in the Strait of Sicily (GSA 16). Nominal and Survey time represent the median day and the chronological time (in year) of the survey; n = number.

Season	Year	Start	End	Nominal time	Survey time	n of hauls	n of females	n of males
Spring	1994	11-June	15-July	28-June	0.50	36	-	-
Spring	1995	3-June	17-June	10-June	1.41	41	-	-
Spring	1996	31-May	12-June	6-June	2.41	41	-	-
Spring	1997	3-June	14-June	8-June	3.41	41	-	-
Spring	1998	16-June	27-June	20-June	4.50	42	-	-
Spring	1999	28-May	9-June	2-June	5.41	42	127	107
Spring	2000	26-May	8-June	31-May	6.41	42	222	181
Spring	2001	19-May	1-June	26-May	7.41	42	125	119
Summer	2002	11-July	24-August	2-August	8.58	66	244	272
Summer	2003	13-July	13-August	28-July	9.58	65	266	314
Summer	2004	10-June	11-July	25-June	10.50	65	294	288
Summer	2005	5-July	13-August	28-July	11.58	108	627	640
Spring	2006	19-May	14-June	01-June	12.41	114	735	828
Summer	2007	10-June	09-July	24-June	13.50	120	1243	1500

upper slope) according to the swept-area principle (ANON., 2007). Frequency of occurrence, *f,* i.e. the percentage of positive (presence of at least 1 specimen) on the total number of hauls, was also computed. A theoretical mean individual body weight ($^*B_W$; g) was also derived ($1000^*B_I\ ^*D_I^{-1}$). As ancillary information, a horizontal spatial representation of D_I (overall, ovigerous females and juveniles) was realized by implementing the "exact interpolator" (IDW, Inverse Distance Weighting) procedure within the GIS software ArcMap™ 9.0 (ESRI, 2004). Size, sex and macroscopic sexual maturity condition of the Blackmouth catshark were measured or evaluated; in particular, total length (*TL*) was measured with graduated steel plates to the nearest (inferior) mm from the distal side of the head to the end of the caudal fin. The individual total body weight (B_W) was recorded (since 2003) with an analytical balance (1g). Each specimen was externally sexed (*F*, females, *M*, males), and females were dissected in order to expose the internal body cavity. Sexual maturity condition was classified in three stages as follows: 1st – virginal/immature; 2nd – juveniles maturing or recovering and 3rd – fully mature (cfr. JARDAS, 1979; CAPAPÉ *et al.*, 2008). Mature/adulthood status was based on the "adult over overall specimens" proportion by size class; "adult" specimens including the stages 2-3.

The allometric formula, $B_M = a\,TL^b$ was applied to both sexes for each year, since 2003, and years combined to estimate the length-weight relationship. The length frequency distributions (10mm class width) were compared according to the Kolmogorov-Smirnov (K_S) non-parametric test; maximum size, L_{max} (FORMACION *et al.*, 1992) and median total length (TL_M) were also estimated.

The sex ratio (S_R), overall and by length size class, was defined as the proportion of females on the total sexed individuals $[F^*(F+M)^{-1}]$ by year and years combined. Given that for Blackmouth catshark S_R of around 0.5 is expected (CAPAPÉ & ZAOUALI, 1977; TURSI *et al.*, 1993; RELINI *et al.*, 1999; RINELLI et al, 2005; CAPAPÉ *et al.*, 2008), the variance was computed according to

$$Var\left(S_R\right) = \sqrt{\frac{S_R \cdot \left(1 - S_R\right)}{\left(F + M\right)}}$$

The significance of the difference between the estimated and expected S_R were evaluated according to a χ^2 test. The consistency and length structures by maturity stage were estimated by computing the corresponding mean and medians (compared by a paired t-test) and analyzing the boxplot representation. The "logistic" size at the onset of sexual maturity (S_M), herein defined as $L_{m50\%}$, was derived (least square regression) according to

$$p_{mk} = \frac{1}{1 + \exp\text{-}\,g \cdot \left(L_k - L_{m50\%}\right)}$$

where p_{mk} represents the proportion of the specimens considered mature in length (L) class k, g is the steepness parameter, and $L_{m50\%}$ denotes the S_M. The maturity range, $L_{m25\%} - L_{m75\%} = 2{*}\log_e(3){*}g^{-1}$, was also computed.

The correlation between S_T (independent variable) and f, B_I, D_I, $^*B_W$, S_R, TL_M and BST (dependent variables) was evaluated (after a semi-$\log_e$ transformation for B_I and D_I), at significant ($P<0.05$) and highly significant ($P<0.01$) level, by ordinary least square linear regression. Linear regression was also employed for the depth-TL_M relationship, whereas a G-test (with 8 degree of freedom) was performed as an overall test of S_R–S_T independence.

Results

The Blackmouth catshark was always sampled in the two deepest strata (201-800m), with the only exception of one small sized (200 mm) male sampled at 128m in 2006. The E- stratum (501-800m) resulted the most frequented habitat (Table 2); in particular, the E-stratum D_I and B_I were 7-27 times higher than the D-stratum indexes. All estimators (f, D_I and B_I) showed significant or highly significant temporal trend in both strata (see Table 2 caption for the estimated coefficients). On the contrary, no significant temporal correlation was detected for $^*B_M$ (D: F-ratio = 0.1, P = 0.740; E: F-ratio = 1.9, P = 0.190), which ranged between 25-90g (mean 45.2g) and 147-238g (mean 177.9g) in the D- and E-stratum, respectively.

The D_I spatial representation (maps available to the Authors) indicated a contagious distribution with hot-spots next to the deep trenches in the area; neither clear spawning nor nursery areas were detected. The mean bottom seawater temperature (BST; °C) ranged between 14.0 and 14.4 (great mean of 14.16) in the D-stratum and 13.8 and 14.0 (great mean of 13.94) in the E-stratum. No significant temporal correlation resulted in the D-stratum (F-ratio = 2.0, P = 0.205), whereas a positive signifi-

Table 2

Frequency of occurrence (*f*), density (D_1; N*km^{-2}) and biomass (D_1; kg*km^{-2}) indexes by depth stratum (D: 201-500; E: 501-800m) evolution with time of *Galeus melastomus. Legenda:* C.V.%, coefficient of variation (D.S.*mean^{-1}); P, probability value; *, significant level, 0.05; ** high significant level, 0.01. Intercept (a), slope (b) and corresponding standard error (±) for the linear regression were: 36.595 ± 5.390, +1.841 ± 0.668, for D-*f*(%); 81.171 ± 3.56, +1.735 ± 0.441, for E-*f*(%); 2.412 ± 0.363, +0.177 ± 0.045, for loge-D-D_1;4.502 ± 0.205, +0.110 ± 0.025, for loge-E-D_1; -0.821 ± 0.250, +0.191 ± 0.031, for loge-D-B_1; and 2.848 ± 0.216, +0.099 ± 0.027, for loge-E-B_1.

Stratum	Statistic	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	P	
D	f(%)	20	45	36	42	55	55	55	64	50	39	67	46	60	59	0.017	*
E	f(%)	80	86	92	69	86	93	100	100	100	100	100	100	100	100	0.002	**
D(DI)	Mean	5	49	25	14	33	40	33	18	69	22	49	90	105	307	0.002	**
	C.V.%	83	68	77	54	62	61	46	40	76	61	54	86	45	73		
E(DI)	Mean	164	109	190	54	97	144	270	167	205	281	269	329	384	506	0.001	**
	C.V.%	33	67	42	39	31	35	27	20	21	24	21	26	25	18		
D(BI)	Mean	0.4	1.2	1.0	0.4	1.0	1.5	1.5	1.6	2.5	1.2	2.8	3.5	4.8	12.7	0.000	**
	C.V.%	85.6	59.1	66.8	56.5	61.2	46.4	67.8	51.3	64.0	62.4	37.5	68.6	48.6	60.5		
E(BI)	Mean	39.1	16.8	28.6	10.1	19.4	27.7	51.6	29.1	31.6	50.8	53.0	48.3	60.9	85.4	0.003	**
	C.V.%	37.8	57.9	37.9	46.9	35.2	34.1	26.8	18.7	19.2	28.1	29.1	20.4	19.2	17.1		

cant (F-ratio = 6.4, P = 0.039) increase of *BST* with S_T was detected in the E-stratum; the intercept and angular (slope) coefficients (with the corresponding standard errors) were 13.855 (± 0.039) and +0.019 (± 0.007).

The allometric coefficients of the length-weight relationship indicated (all years combined) an almost isometric condition ($b \approx 3$) for both females ($b = 3.02$; $a = 2.7 \cdot 10^{-6}$) and males ($b = 2.95$; $a = 4.1 \cdot 10^{-6}$), the former showing a slight higher coefficient than the latter. The year *b* value ranges were 2.97-3.05 and 2.92-2.99 in females and males, respectively.

Females and males showed an almost complete overlapping length composition (Table 3). The overall median resulted 330 and 340 in females and males, respectively, with not significant temporal correlation (F: F-ratio = 4.8, P = 0.065; M: F-ratio = 0.5, P = 0.521). The length frequency distribution (LFD; Fig. 2) shape by females and males showed multiple overlapping modes and a prevalence of medium and large sized specimens; the size classes ranged between 75-595 (females) and 95-515 (males) mm. In general, all size groups above 150-200mm were well represented; no significant differences among years were detected according to the K_S test. The maximum sizes (extreme values theory) were 578.7 and 519.9mm, with corresponding ranges of 558-599 and 507-533mm, in females and males, respectively.

The sex ratio by survey (Table 4) showed a significant departures from the expected 0.5 value in 4 out 9 years and a significant decreasing temporal correlation (F-ratio = 11.1, P = 0.013), with intercept and slope coefficients (± the corresponding standard errors, s.e.) of 0.539 (± 0.016) and -0.010 (± 0.003). The year effect was also confirmed after the G-test (G-value = 25.16 *vs* χ^2.= 20.09; P<0.01). Considering the S_R by length class (Fig. 3), females decrease up to 450 mm increasing thereafter (up 1.0 in the largest sizes).

The depth-length relationship (Fig. 4) indicated an almost coincident pattern in females and males: a wide size range in all depth levels and a paired evolution in median length, which increases (with a slight inflexion around 500m) from 140(*F*)-145(*M*) at 201-300m to 175-170 at 301-400m, 230 (*F* and *M*) at 401-500m, 340-330 at 501-600m, 385-375 at 601-700 m, and 415-425 at 701-800m. A highly significant (P < 0.001) correlation was detected with slope coefficient (±s.e.) of 0.566 ± 0.017 and 0.563 ± 0.015 for females and males, respectively (0.565 ± 0.011 for sex combined).

The size at maturity stage analysis (Fig. 5a,b; Table 5) indicated, for both sexes, a satisfactory resolution capability of the adopted scale, the prevalence of the 1st (77 and 65% in females and males) stage and a mean almost always lower than the corresponding median in both females and males. With the exception of the 2nd stage in males (P = 0.571), the difference between the two estimators resulted (one-way paired t-test) always significant or highly significant (Females: 1st, P <0.01; 2nd, P = 0.047; 3rd, P = 0.027; Males: 1st, P < 0.01; 3rd, P = 0.012). Considering the median length at stage by time, no significant temporal correlation resulted in both females (1st, P = 0.053; 2nd, P = 0.296; 3rd, P = 0.618) and males (1st, P = 0.536; 2nd, P = 0.607; 3rd, P = 0.892).

The logistic fits of the matures/all specimens proportions resulted in an overall $L_{m50\%}$ and corresponding maturity range ($L_{m25\%}$ - $L_{m75\%}$) of 433 (423-443) and 380 (366-394) mm in females and males, respectively (Fig. 6a,b; Table 5). Temporal correlation was significant in both sexes,

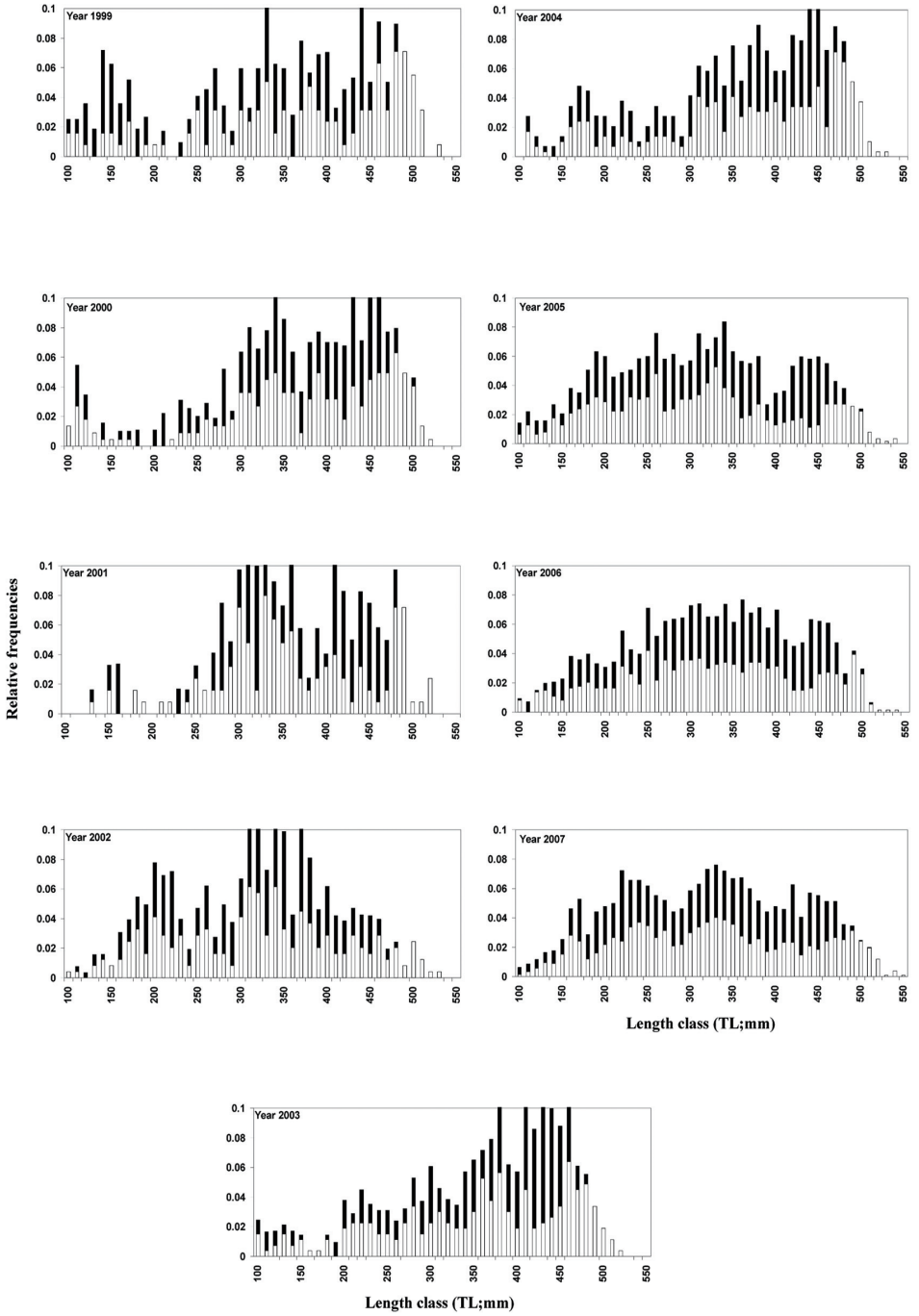

Fig. 2: *Galeus melastomus* relative length frequency distribution by year and sex (white bars for females and black bars for males).

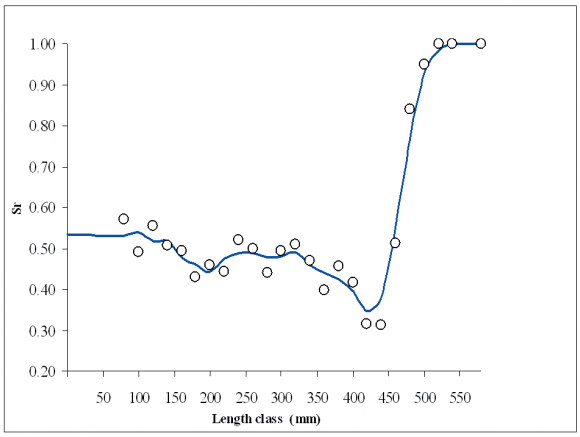

Fig. 3: *Galeus melastomus* sex ratio (S_R) *vs* size class plot (all years combined) with overimposed the interpolation line.

Table 3

Length composition characterisation of *Galeus melastomus* according the box plot approach, by year, years combined and sex. *Legenda:* P, probability value; ns, not significant (P >0.05).

Sex	Box plot statistics	1999	2000	2001	2002	2003	2004	2005	2006	2007	99-07	P	
Females	Higher quartile	470	460	440	390	450	460	380	400	410	420		
	Median	380	390	350	320	370	390	310	320	320	330	0.065	ns
	Lower quartile	300	313	310	248	280	310	230	250	240	250		
Males	Higher quartile	400	430	430	370	430	440	410	400	400	410		
	Median	330	360	360	320	390	380	320	330	320	340	0.521	ns
	Lower quartile	190	310	310	238	300	288	240	260	230	250		

Table 4

Parameters and statistics concerning the overall sex ratio (S_R) of *Galeus melastomus* by year and years combined. *Legenda:* n, ns, (*) and (**) denote number, not significant, significant and highly significant test, respectively.

Statistics	1999	2000	2001	2002	2003	2004	2005	2006	2007	99-07
n Females	127	222	121	244	266	294	627	735	1243	3879
n Males	107	181	115	272	314	288	640	828	1500	4245
Mean S_R	0.54	0.55	0.51	0.47	0.46	0.51	0.49	0.47	0.45	0.48
Variance S_R	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01
χ^2 (value)	1.71	4.17	0.15	1.52	3.97	0.06	0.13	5.53	24.08	16.49
χ^2 (Significance)	ns	*	ns	ns	*	ns	ns	*	**	**

Table 5
Galeus melastomus **synthetic representation of the consistency, mean length and corresponding C.V., and box-plot parameters by sex and maturity stage along with the $L_{m50\%}$ by sex according the logistic fit.**

Sex	Statistics	Stage 1			Stage 2			Stage 3		
		Min	Max	Overall	Min	Max	Overall	Min	Max	Overall
Females	n%	59	86	77	3	19	6	12	28	17
	Mean	274	325	289	431	463	447	474	485	480
	C.V.%	18	31	29	6	9	7	4	11	6
	Higher quartile	335	380	350	448	480	470	490	500	500
	Median	280	330	300	440	470	450	480	490	480
	Lower quartile	210	300	230	420	450	430	460	480	470
	$L_{m50\%}$ - logistic				Min.	394	Max.	440	Overall	433
		Min	Max	Overall	Min	Max	Overall	Min	Max	Overall
Males	n%	49	77	65	6	19	9	9	37	25
	Mean	237	314	271	366	437	398	432	444	436
	C.V.%	19	39	28	6	12	8	5	9	7
	Higher quartile	320	350	330	393	460	420	450	460	450
	Median	245	320	280	360	450	400	430	450	440
	Lower quartile	150	280	210	340	420	380	410	430	420
	$L_{m50\%}$ - logistic				Min.	377	Max.	388	Overall	380

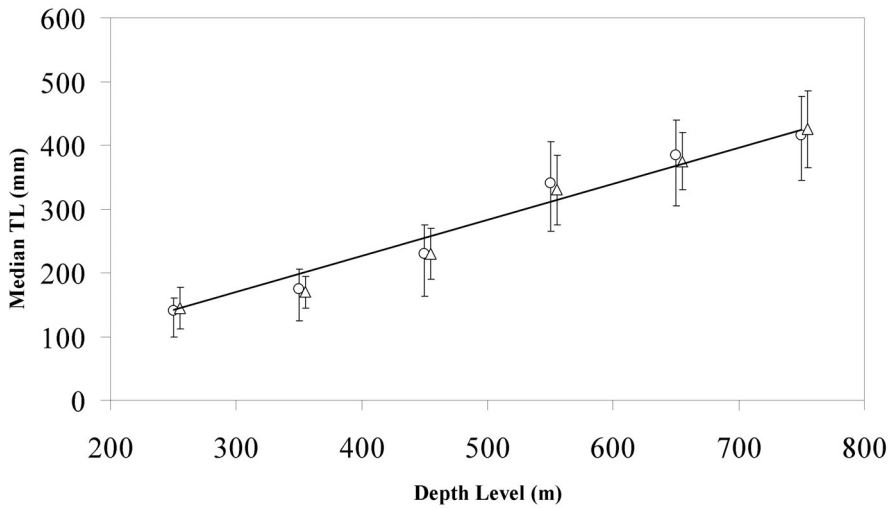

Fig. 4: *Galeus melastomus* median total length (TL) *vs* depth interval (100m wide, starting from 201m) representation (all years combined) for females (dots) and males (triangles). The vertical and straight lines indicate the Higher and Lower interquartiles and the depth – median regression for sex combined (slope = 0.565; s.e. = 0.011).

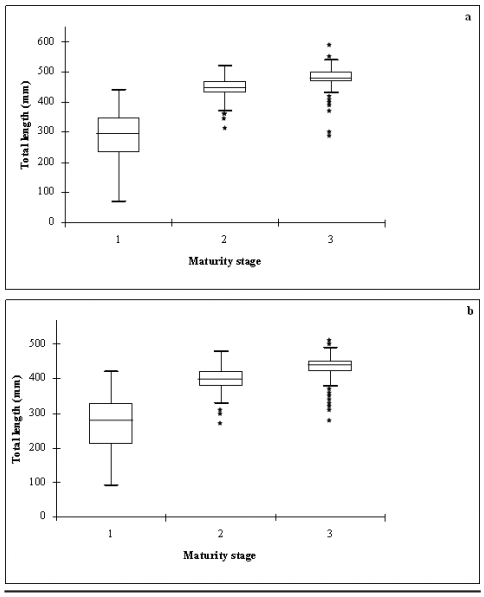

Fig. 5a,b: *Galeus melastomus* overall (all years combined) box-plot representation of length structure by sex (females, a, and males, b) and maturity stage.

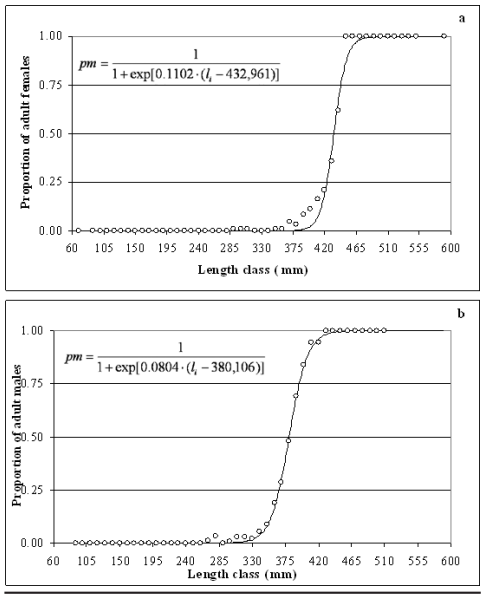

Fig. 6a,b: *Galeus melastomus* overall (all years combined) logistic fit of adult proportions by females (a) and males (b).

but with opposite tendency: increasing (385.9 ± 11.96, + 4.12 ± 1.216, F-ratio = 11.5, P = 0.012) in females, and decreasing (393.9 ± 4.38, -1.23 ± 0.427, F-ratio = 8.8, P = 0.025) in males.

Discussion

Present results concerning the bottoms of the Strait of Sicily, between 10 and 800m of depth, support the most common distribution pattern of the Mediterranean Blackmouth catshark populations: the species occurrence is occasional between 150-250m, regular (but with low densities) between 201-500m, and regular and abundant between 501-800m (RELINI *et al.*, 1999; BAINO *et al.*, 2001; REY *et al.*, 2005). An upper displacement of the depth preferential, in fact, was reported only in northern latitudes (DELATTRE & MAIGRET, 1986; CAPAPÉ *et al.*, 2008). Bottom seawater temperature does not seems the main explaining abiotic parameter of the distribution given the slight differences observed in the two strata; it is likely that other factors, such as light penetration (cfr. BOZZANO *et al.*, 2001) might play an important role.

The lowest bathymetric limit of *G. melastomus* could not be determined in the present contribute, and no information is available for waters deeper than 800m in the Strait of Sicily. Both past (CARRASSÓN *et al.*, 1992; STEFANESCU *et al.*, 1992) and recent (UNGARO *et al.*, 2001; SARDÀ *et al.*, 2004b) deep waters bottom trawling or baited video camera (JONES *et al.*, 2003) surveys in other Mediterranean basins clearly indicate *G. melastomus* as an important component of both upper and middle slopes fishing assemblages (D'ONGHIA *et al.*, 2004; MORANTA *et al.*, 2004) with an abundance peak at intermediate depth level (700-1000m; MORANTA *et al.*, 2004).

Taking into account the comparison of MEDITS indexes derived throughout the Mediterranean basins with the same gear/methodologies and similar temporal sampling periods (RELINI *et al.*, 1999; BAINO *et al.*, 2001), the abundance of *G. melastomus* in the Strait of Sicily can be considered among the highest obtained. On the contrary, given the narrow temporal coverage of the present surveys, it is difficult to compare both seasonality and temporal trend about which no clear or even contrasting patterns are reported in literature (BAINO & SERENA, 2000; RAGONESE *et al.*, 2001; ABELLA & SERENA, 2005; FERRETTI *et al.*, 2005). The significant increase in the abundance indexes of the Strait of Sicily population is similar to the slight increase – stable condition reported for the Tyrrhenian Sea population (BAINO & SERENA, 2000; ABELLA & SERENA, 2005; FERRETTI *et al.*, 2005) and could reflect a reduction in fishing mortality, a recruitment increase or an improvement in the habitat features. However, significant temporal effects were not detected in $^{*}B_{W}$, TL_{M} (overall and by maturity stage) and LFD, hence, the observed increase in the *AI* might likely reflect a best matching between the increased sample size and the contagious distribution of the species.

As regards the Mediterranean *G. melastomus* length composition, present LFD are more coherent with those characterized by a higher consistency of middle-large rather than lower sized class (RELINI *et al.*, 1999; UNGARO *et al.*, 2001; REY *et al.*, 2005). LFD with a prevalence of small-medium sized specimens were also reported (CAMPILLO, 1992; TURSI *et al.*, 1993; ABELLA & SERENA, 2005; RINELLI *et al.*, 2005), but might be associated to sam-

pling limitations such as the depth range covered (cfr. REY *et al.*, 2005) in respect to the local length by depth distribution pattern (cfr. the large specimens detected below 600 m in the NW-Ionian Sea; SION *et al.*, 2004). As a matter of fact, the length by depth distribution pattern appears coherent with the 4th hypothesis proposed by MORANTA *et al.* (2004) to explain the biomass peak at intermediate level in the deep fish assemblages: *G. melastomus* lengths tend to increase up a maximum at intermediate depth level, thereafter tend to decrease. Since the youngest specimens occur almost exclusively in shallower depths, juveniles and adults share the upper and lower slope bottoms, and adults prevail at intermediate depth levels, the occurrence of slight pattern variation may explain the apparent contrasting findings of increasing (CARBONELL *et al.*, 2003; REY *et al.*, 2005; RINELLI *et al.*, 2005; present study), stable (TURSI *et al.*, 1993) or even decreasing (SION *et al.*, 2004) local length by depth relationships.

As regards the length structure, it is to remark how sex related differences concerns mainly the maximum lengths achieved, the bulk of the two components being almost perfectly overlapping, as the general case for the Mediterranean populations (cfr. RINELLI *et al.*, 2005). No clear trend can be found in literature for this parameter, which is considered affected by intrinsic variability in Scyliorhinidae (CAPAPÉ & BEN BRAHIM, 1984). Considering the ever maximum length, and excluding (for the Mediterranean) the anecdotal and not documented 900 mm record (TORTONESE, 1956), females are generally considered as those specimens achieving the largest size (COMPAGNO, 1984). Indeed, the L_{max} range varies within and among the different basins: 620-F *vs* 580-M (Alboran Sea, but after the exclusion of a single 630 male; REY *et al.*, 2005), 620 *vs* 550 (Balearic Sea; SION *et al.*, 2004), 640 *vs* 620 (South of France; CAPAPÉ *et al.*, 2008), 550 *vs* 550 (Southern Tyrrhenian; RINELLI *et al.*, 2005), 660 *vs* 620 (Tunisian waters; CAPAPÉ & BEN BRAHIM, 1984, but 560 *vs* 550 in the same area according to CAPAPÉ & ZAOUALI, 1977), 550 *vs* 510 (NW-Ionian; TURSI *et al.*, 1993; SION *et al.*, 2004), and 510 *vs* 480 (E-Ionian Sea; SION *et al.*, 2004). Present figures, 595 *vs* 515, although based on a statistical criterion, are coherent with the general pattern.

The L_{max} variability by sex has no practical effect on the length weight relationship: present results show an isometric condition in both females and males of *G. melastomus,* with only a slight higher allometric coefficient values in the latter. This pattern corresponds to the published data where the b coefficients ranges between 2.96-3.21 and 2.99-3.13 for females and males, respectively (RELINI *et al.*, 1999; RINELLI *et al.*, 2005); the negative allometric coefficients (2.89 in females and 2.76 in males) reported by CAPAPÉ *et al.* (2008), likely reflects the relative low presence of juveniles. Neither sex (RINELLI *et al.*, 2005; CAPAPÉ *et al.*, 2008) or seasonal (RINELLI *et al.*, 2005) related differences were detected. The higher b values in females than males likely reflects reproductive exigencies, such as the storage of reserve for the vitellogenesis (CAPAPÉ *et al.*, 2008).

The overall sex ratio for this species did not revealed any clear pattern since all possible combinations were found in literature: ~ 0.5 (Tunisian waters, CAPAPÉ & ZAOUALI, 1977; Italian waters, RELINI *et al.*, 1999; Southern Tyrrhenian, RINELLI et al, 2005; South of France, CAPAPÉ *et al.*, 2008: present study); < 0.5 (deep waters of Ligurian Sea, RELINI-ORSI &

WURTZ, 1975; Alboran Sea, REY *et al.*, 2005) and > 0.5 (Eastern Mediterranean, GOLANI, 1986/87; Adriatic, UNGARO *et al.*, 1997). On the contrary, it is worth noting the analogy between present S_R by size results and those obtained in the Alboran Sea (Fig. 7 in REY *et al.*, 2005): the S_R remains almost stable around 0.5 till a transitional size class is achieved; thereafter the S_R sharply reduces to increase again above the 0.5 in the largest size class. The most interesting feature is that in both populations there is a correspondence between the transitional size class range and the size at maturity for males (440-540 *vs* 443, and 340-440 *vs* 380, for the Alboran Sea and the Strait of Sicily).

Present estimations of the size at maturity were more comparable with the figures obtained in the Tunisian waters (CAPAPÉ & ZAOUALI, 1977) and South Tyrrhenian (RINELLI *et al.*, 2005), but slight lower than other Mediterranean basins (RELINI *et al.*, 1999; REY *et al.*, 2005; CAPAPÉ *et al.*, 2008). According a general interpretation, already formalized *in nuce* for *S. canicula* (LELOUP & OLIVERAU, 1951; CAPAPÉ, 1977; MELLINGER *et al.*, 1984), both Atlantic and Mediterranean females and males of *G. melastomus* will be able to reach the same maximum size following a common potential double growth trajectories, with a maturity-transition between fast- and slow- format occurring earlier in warm waters (LELOUP & OLIVERAU, 1951) and in males (as the general case in sharks; CORTÉS, 2000). This scenario finds a theoretical support in STAMPS *et al.* (1998): the asymptotic size in iteroparous and long living marine fish is directly related to the size at sexual maturity and, consequently, the largest maximum size will be achieved (given the other variable equal) by specimens who delay sexual maturity. Beside that anomalies in sexual apparatus are quite common in Scyliorhinids (cfr. ELLIS & SHACKLEY, 1997), "extra spent" specimens, i.e. large sized individuals showing "adult" body conformation, but juvenile-abortive-atresic gonads, were reported in both Atlantic *S. canicula* (females of 600 mm; RODRÍGUEZ-CABELLO *et al.*, 1998) and *G. melastomus* (two 720 mm specimens, BORCEA, 1908, in CAPAPÉ & ZAOUALI, 1977; CAPAPÈ *et al.*, 2008).

Finally, the general stability and similar patterns in the abundance indexes and biological features observed in *G. melastomus,* in spite of the general over exploitation status of almost all the Mediterranean demersal resources (PAPACONSTANTINUOU & FARRUGIO, 2000), support the general idea that the wider vertical distribution of *G. melastomus,* which extends below the range of commercial trawling (around 700-800m close to the limit of 1000m, recently adopted within the European Union Common Fisheries Policy; EU Council Regulation 1967/2006), might mitigate the fishing pressure and determines a sustainable steady state for this shark (cfr. CAPAPÈ *et al.*, 2008); for the Strait of Sicily, however, a corollary of this hypothesis is that present sustainability could be menaced by allowing an increase of gill nets and bottom longlines fisheries in grounds below 800-1000m depths.

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Submitted: January 2009
Accepted: April 2009
Published on line: June 2009