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Distribution and Biology of the Blackmouth Catshark *Galeus melastomus* in the Alboran Sea (South-western Mediterranean)

(Elasmobranch Fisheries – Oral)

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Abstract

The distribution, population structure and reproductive biology of *Galeus melastomus* in the Alboran Sea was studied from 438 bottom trawls performed from 40 to 796 m depth during twelve cruises carried out between 1994 and 2002. The species was only captured at the two deepest strata (below 200 m), reaching its maximum abundance and biomass between 501 and 800 m depth. Maximum indices were obtained in 1997 and 2002, without any specific trend in abundance, while biomass showed a slightly decreasing trend from 1994. Similarly, seasonal variation of abundance and biomass over the last two years showed maximum values of biomass in autumn and none trend in abundance. Size of specimens ranged from 10 to 63 cm and all size groups were well represented in length frequencies during all seasons. Juveniles and adults were restricted to depths below 500 m, while recruits were distributed along the whole bathymetric range in which the species was found. Both recruitment and spawning were continuous throughout the year and length of first maturity was calculated at 44.3 and 48.8 cm total length by males and females, respectively. Finally, the great abundance and biomass of the species as well as its wide population structure were compared and discussed with those of other Mediterranean areas.

Keywords.- *Galeus melastomus*, abundance, distribution, population structure, reproduction, Alboran Sea, south-western Mediterranean.

Introduction

The Blackmouth catshark *Galeus melastomus* Rafinesque, 1810 (Scyliorhinidae) is a small elasmobranch distributed in the eastern Atlantic Ocean, from Norway to Senegal, and in the whole Mediterranean Sea (Compagno, 1984). It shows a wide bathymetric distribution range along the Mediterranean, in which it has been captured from 55 to 1750 m depth (Stefanescu *et al*., 1992; Relini *et al*., 1999) and, in the western basin, it can be considered as an abundant species on demersal assemblages between 400 and 1400 m depth (Moranta *et al*., 1998).

In the Mediterranean, studies have been developed to analyse the distribution, behaviour and biology of *Galeus melastomus*, mainly in the central area. Among them, it can be cited those developed off the Tunisian coast by Capapé and Zaouali (1976, 1977) and in Italian waters by Relini Orsi and Wurtz (1975, 1977), Sartor and Ranieri (1995), Tursi et *al*. (1993), Ungaro *et al*. (1997) and Scacco *et al*. (2002). In the western basin, the only studies have

been developed off the north-eastern Iberian and focussed on its distribution and feeding behaviour (Macpherson, 1980; Carrasón *et al*., 1992; Bozzano *et al*., 2001).

In the Alboran Sea, *Galeus melastomus* shows the highest abundance and biomass densities of the whole northern Mediterranean (Bertrand *et al*., 2000) and it is the most important species of by-catch in the recently developed bottom trawl fishery targeted to the deep-water shrimp *Aristeus antennatus* (Torres *et al*., 2001). Despite of this, little is known about this shark. The only available information can be found in Gil de Sola (1994), where an insight about the distribution of demersal fishes up to 500 m depth is reported.

Distribution, population structure and reproductive biology of *Galeus melastomus* from trawling fishing grounds along the continental shelf and upper slope of the Alboran Sea (south-western Mediterranean) are presented in this paper. Its aim is to correct the lack of information about the species in the area. This knowledge, together with those of other species, will allow the future assessment of these new deep-water fisheries and their possible effects on the very unknown bathyal ecosystems of the Alboran Sea.

Material and Methods

Data and samples were collected from 438 bottom trawls developed during twelve cruises carried on the Alboran Sea off the south-eastern Iberian coast (Fig. 1). Nine of these surveys (MEDITS) were carried out during spring, from 1994 to 2002, on board the R/V "Cornide de Saavedra", while three of them (MERSEL) were developed during summer 2001, autumn 2001 and winter 2002, on board the R/V "Francisco de Paula Navarro" (Table 1). These hauls were developed on trawl fishing grounds along the continental shelf and upper slope from 40 and 796 m depth. In all these surveys, a random stratified sampling scheme was applied and a GOC73 (on average, horizontal and vertical openings of 16.4 and 2.8 m, respectively) gear was used, following the protocols of most surveys developed actually along the Mediterranean Sea (MEDITS programme; Bertrand et *al*., 1998).

In each trawl, fresh weight in grams and number of *Galeus melastomus* were recorded and the total length, by sex, of specimens were measured to the nearest lower centimetre. Data was standardised taking into account the arrival and departure of the net to the bottom, measured using a SCANMAR system. Following the standard procedures of the MEDITS programme, the indices of abundance and biomass were computed, as stratified mean and variance, for the whole surveyed area and for the following five bathymetric intervals considered: (i) 10-50 m; (ii) 51-100 m; (iii) 101-200 m; (iv) 201-500 m; (v) 501-800 m. Temporal and bathymetric variations on the population structure were analysed under the same procedure (Table 1).

To obtain an expression describing the depth-size trends of this species, a simple linear regression analysis for the two variables mean size and depth was calculated. Thus, only hauls in which more than 20 specimens were captured, have been considered. The coefficient of determination (r^2) was also calculated to determine what proportion of the total variation in size is explained by change in depth.

To analyse reproductive aspects of the species, biological sampling of total catch, or of random subsamples, was also made during the five cruises developed on 2001 and 2002 (Table 1). Maturity stages were determined by macroscopic examination of the gonads, following a four points scale for females (1: immature; 2: maturation; 3: spawning; 4: post spawning) and a three points scale for males, in which stages 3 and 4 were joined together, since they did not present an observable morphological change. Chi-squared test was applied to assess differences in sex-ratio for the whole population and by length interval, as well as in the percentage of different maturity stages by season.

Data from surveys in which mature specimens were found could be used to calculate size of first maturity (length at which 50% of fish had become mature) in both sexes. For this purposes, the percentage of mature males and females (maturity stages 2, 3 and 4) for each size class were fitted into a minimum square curve.

Results

Distribution and population structure

A total of 25983 specimens of *Galeus melastomus*, weighing 4480 Kg, were caught in 40% of the trawls analysed. In all spring surveys studied (Fig. 2), the species was captured only at two deepest strata surveyed, reaching its maximum abundance and biomass between 501 and 800 m. With the only exception of three individuals captured during a trawl developed at 283 m depth, the species appeared below 300 m depth.

Along the nine years period considered (Fig. 2), maximum indices were obtained in 1997 and 2002, both at 201-500 and 501-800 m depth-strata, with values of 74-94 and 276-373 fish/h, respectively. For biomass indices, maximum were also obtained in 1997 and 2002 at 501-800 m depth-strata (55-66 Kg/h), but not at 201-500 m depth-strata, which historical data series seemed to show a decreasing trend from 1994, with maximum values of 3 Kg/h.

Seasonal variations in abundance and biomass indices for the whole surveyed area were analysed from surveys carried out on 2001 and 2002 (Fig. 3). A clear maximum in biomass were obtained in autumn 2001 (38 Kg/h), while winter, spring and summer values were similar and ranged between 15 and 23 Kg/h. By contrast, abundance did not show any specific trend, with maximum values in autumn 2001 (151 fish/h) and winter and spring 2002 (132 and 141 fish/h, respectively).

A total of 8853 specimens of *Galeus melastomus* were measured. Overall length frequency distribution by sex during spring were plurimodal (Fig. 4), with sizes ranging between 10 and 62 cm for females and between 10 and 63 cm for males. Omitting this last isolated value, maximum size for males was 58 cm, though females usually get the largest sizes. In general, all size groups were well represented, with a constant presence of lengths between 20 and 55 cm along the whole period analysed. Nevertheless, some differences were observed among years, being specimens smaller than 20 cm not only well represented in 1995, 1997 and 2002 but also showing a clear mode at 14 cm in 2002.

Seasonal length frequency distributions by depth-strata (Fig. 5) showed that specimens between 201 and 500 m depth were almost all smaller than 20 cm, although they were also distributed at 501-800 m depth-strata. Specimens bigger than 20 cm were almost restricted in the 501-800 m range. Specimen smaller than 30 cm were present in every season, pointing up a very clear mode between 13 and 18 cm obtained in spring 2002 between 201 and 500 m depth. In each season, fish bigger than 30 cm were also well represented, with clear modes at 50-52 cm. On the other hand, medium sized specimens only showed clear modes at around 35 cm in winter and spring 2002, although they were well represented in every season.

This different bathymetric distribution of sizes was also obtained from the results of the regression analysis between depth and size, which showed significant changes ($r_{0.001,\ 45}$), with an increase of the mean size with depth (Fig. 6), according to the following expression:

Total length (cm)= -12.453 + 0.0823 * Depth (m); n= 47; r= 0.88.

Reproductive aspects

Based on data from 1629 specimens, males were significantly more abundant than females (1.7:1; $p<0.05$, Chi-square test) on the whole population of *Galeus melastomus* distributed along the upper slope of the Alboran Sea. Differences in the percentage of sexes by length class were also obtained (Fig. 7), being both sexes equally represented from 10 to 44 cm ($p>0.05$, Chi-square test). In bigger sizes, males were more abundant between 45 and 54 cm ($p<0.05$, Chi-square test), while females predominated from 55 cm to the maximum length observed ($p<0.05$, Chi-square test).

Post-spawning females presented expanded uterus and were considered to have spawn recently. Number of capsules found in spawning females fluctuate from one to four by uterus. Both for males and females, spawning and post-spawning specimens were found in each season (Fig. 8), with no significant differences in the proportion of spawning and post-spawning for both sexes ($p>0.05$, Chi-square test).

Smallest mature male and female were 42 cm and 45 cm, respectively and size at first maturity was calculated at 48.8 cm for females (r= 0.87) and at 44.3 cm for males (r= 0.97). Although reproductive adults represented almost 25% of the whole population in each season, most of the population was made up of pre-reproductive individuals, due to the wide size range and the late maturation.

Discussion

Our results revealed that *Galeus melastomus* in Alboran Sea is found exclusively on slope bottoms below 200 m depth, showing a regular presence below 300 m depth and the highest abundance and biomass indices between 501 and 800 m depth. Thus, although the present data allow the accurate definition of its upper distribution limit in the area, the fact that the species reached its maximum at the deepest strata surveyed and it is present at the maximum depths explored (796 m), do not allow to determine its lower bathymetric limit. Since Carrasón *et al.* (1992), northwards Iberian coast, the species was abundant from 1000 to 1400 m, but declining very sharply and becoming rare below this depth.

Considering that highest frequencies of occurrence for the species in a nearly area southern Balearic Islands were reached between 400 and 800 m and decreased below this depth (Moranta *et al.*, 1998), the maximum abundance and biomass obtained in the present study can be considered as representative for the species in the area. Taking into account the comparison of densities along the whole northern Mediterranean, made by Bertrand *et al.* (2000) using the same gear and sampling scheme, the abundance and biomass indices of *Galeus melastomus* in the Alboran Sea can be considered as the greatest obtained for the species in the Mediterranean.

Length frequency distributions showed a very wide size range, with all size groups well represented in the population and a constant presence along the whole study period and in every season of recruits as well as juveniles and adults. Nevertheless, a greater abundance of big than medium sized fish has been observed within the population, which could be in accordance with the hypothesized ontogenic variations in the behaviour of this species (Scacco *et al.*, 2002). Since these authors, medium sized specimens have higher mobility, which could lead to move actively in the water column, conferring on them the possibility to avoid capture by trawl net.

The bathymetric distribution of young and adult *Galeus melastomus* in Alboran Sea followed the general pattern of other Mediterranean (Relini Orsi and Wurtz, 1977; Tursi *et al.*, 1993) and Atlantic (Figueiredo *et al.*, 1995) areas, with the youngest specimens mostly concentrated in shallower depths (300-500 m), whereas adult specimens only were distributed below 500 m. Although these results and the increase of mean size with depth obtained could suggest a bathymetric segregation of sizes by ontogenic migration, the limited depth range surveyed did not allow any conclusion. In fact, results obtained in the northwestern Mediterranean showed the presence of immature and adults from 10 and 61 cm at 1400 m depth (Carrasón *et al.*, 1992).

The continuous recruitment was in agreement with the presence of mature fish all year round and was on the basis of the non-existence of any seasonal trend in abundance indices. These results supported the idea of a continuous reproductive cycle (spawning and recruitment) in the study area, as has been reported in other Mediterranean areas (Capapé and Zaouali, 1977; Tursi et *al.*,1993). Sizes of first maturity obtained were also similar to those given by Ungaro et *al.* (1997) and Tursi et *al.* (1993) in Italian waters, but bigger than the reported by Capapé and Zaouali (1977) off Tunisia.

Population structure of the species in the studied area, with a high percentage of adult fish, showed clear differences with the results obtained by Tursi *et al.* (1993) in the Ionian Sea, which consisted mostly of young individuals. Since these authors, it could be attributed to the overfishing carried out at the bathyal depths in their study area. In fact, elasmobranchs are intensively affected by fishing pressure. For these reasons, the great abundance of *Galeus melastomus* in the Alboran Sea with respect to other Mediterranean areas, as well as its wider population structure, as has also been shown for a teleost species (Massutí *et al.*, 2001), could be the results of a low fishing exploitation level applied at the deepest strata surveyed (below 500 m). In fact, deep-water fisheries along the wide slope of the Alboran Sea (almost 9000 Km^2 between 200 and 800 m depth) are restricted to the Alboran Island, Gulf of Vera and some submarine canyons around Cape of Gata, while the open slopes of the western Alboran Sea have remained almost unexploited below 500 m depth (Gil de Sola, 1993; Torres *et al.*, 2001).

Acknowledgements

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Table 1. Sampling cruises (date, depth range and number of hauls) developed in the Alboran Sea (south-western Mediterranean) and sampling collections (catch data, specimens measured and biological sampling) of *Galeus melastomus* analysed in this study.

Surveys	Date	Depth (m)	Hauls	Catch data		Length	Biological
				Number	Weight (g)	sampling	Sampling
MEDITS0694	28/05-14/06/94	41-786	25	882	177232	522	
MEDITS0595	22/04-21/05/95	47-771	27	2281	430759	520	
MEDITS0596	02/05-26/05/96	44-776	33	4047	609791	689	
MEDIT S0597	10/05-03/06/97	46-728	33	4467	680460	1656	
MEDITS0598	04/05-14/05/98	47-707	32	2818	405115	610	
MEDITS0599	04/05/-13/05/99	46-790	39	1918	372328	592	
MEDITS0600	22/05-01/06/99	45-776	38	2082	410377	641	
MEDITS0501	12-22/05/01	44-796	38	1792	467309	897	610
MERSEL0801	01-17/08/01	40-790	44	2417	156712	733	139
MERSEL1001	14/10-03/11/01	44-704	45	946	231021	426	209
MERSEL0302	05-20/03/02	46-724	40	1014	169542	450	128
MEDITS0502	11-22/05/02	43-760	44	1319	369029	1117	611
Total		40-796	438	25983	4479675	8853	1697

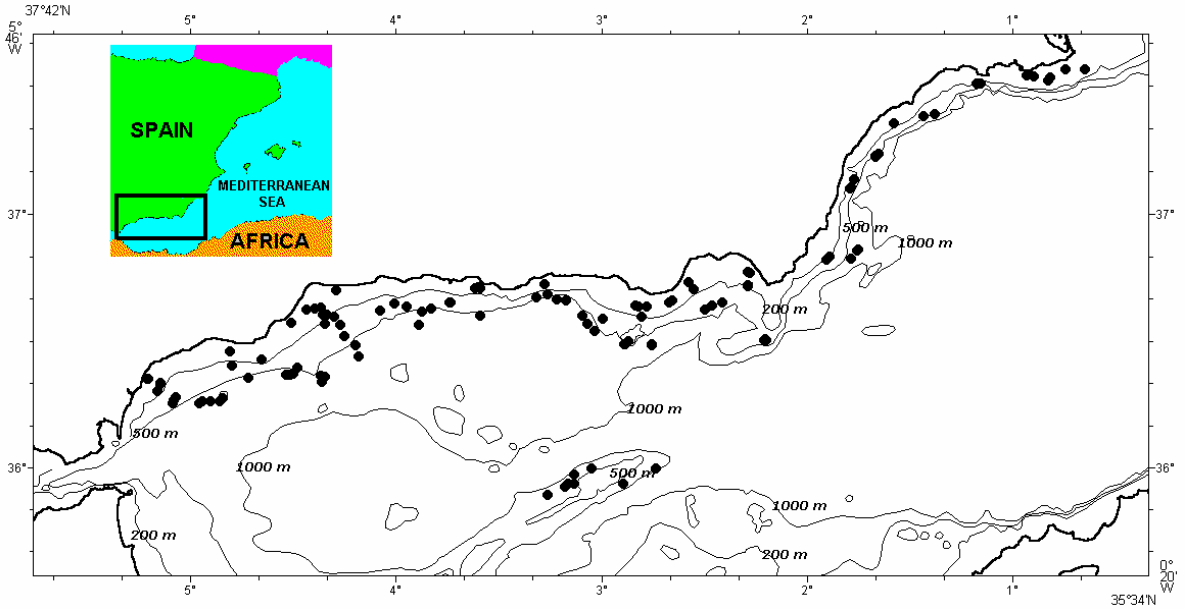

Fig. 1. Location of the studied area (Alboran Sea, north-western Mediterranean), showing the trawl stations surveyed and the 200, 500 and 1000 m isobaths.

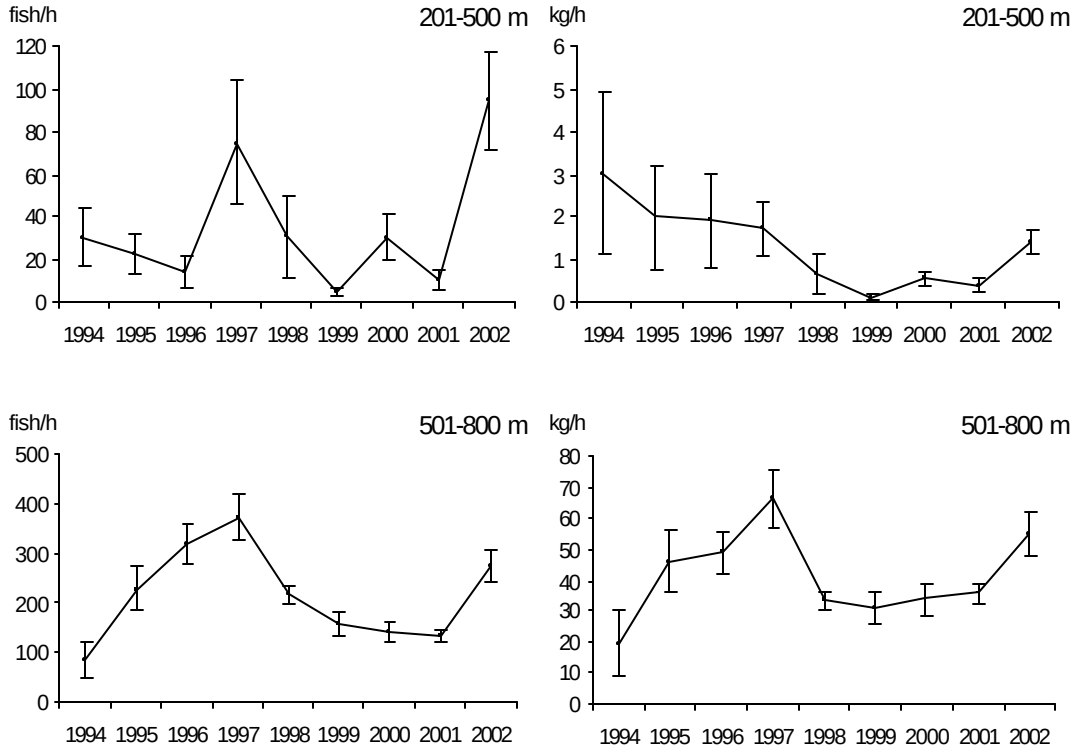

Fig. 2. Historical data series of standardised mean abundance (Fish/h) and biomass (kg/h), obtained by depth-strata in which *Galeus melastomus* was captured from spring MEDITS surveys in Alboran Sea. The confidence intervals at 95% are shown.

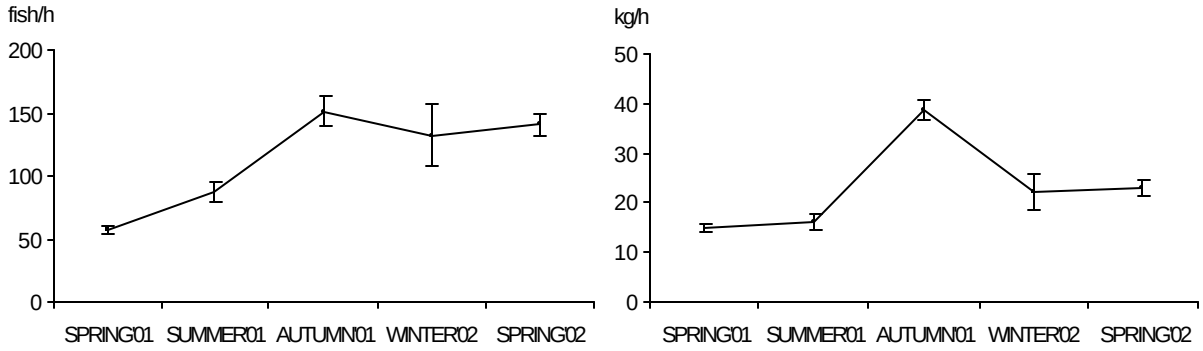

Fig. 3. Seasonal standardised mean abundance (fish/h) and biomass (kg/h) of *Galeus melastomus*, calculated from MEDITS (spring 2001 and 2002) and MERSEL (summer and autumn 2001 and winter 2002) surveys for the whole surveyed area in Alboran Sea. The confidence intervals at 95% are shown.

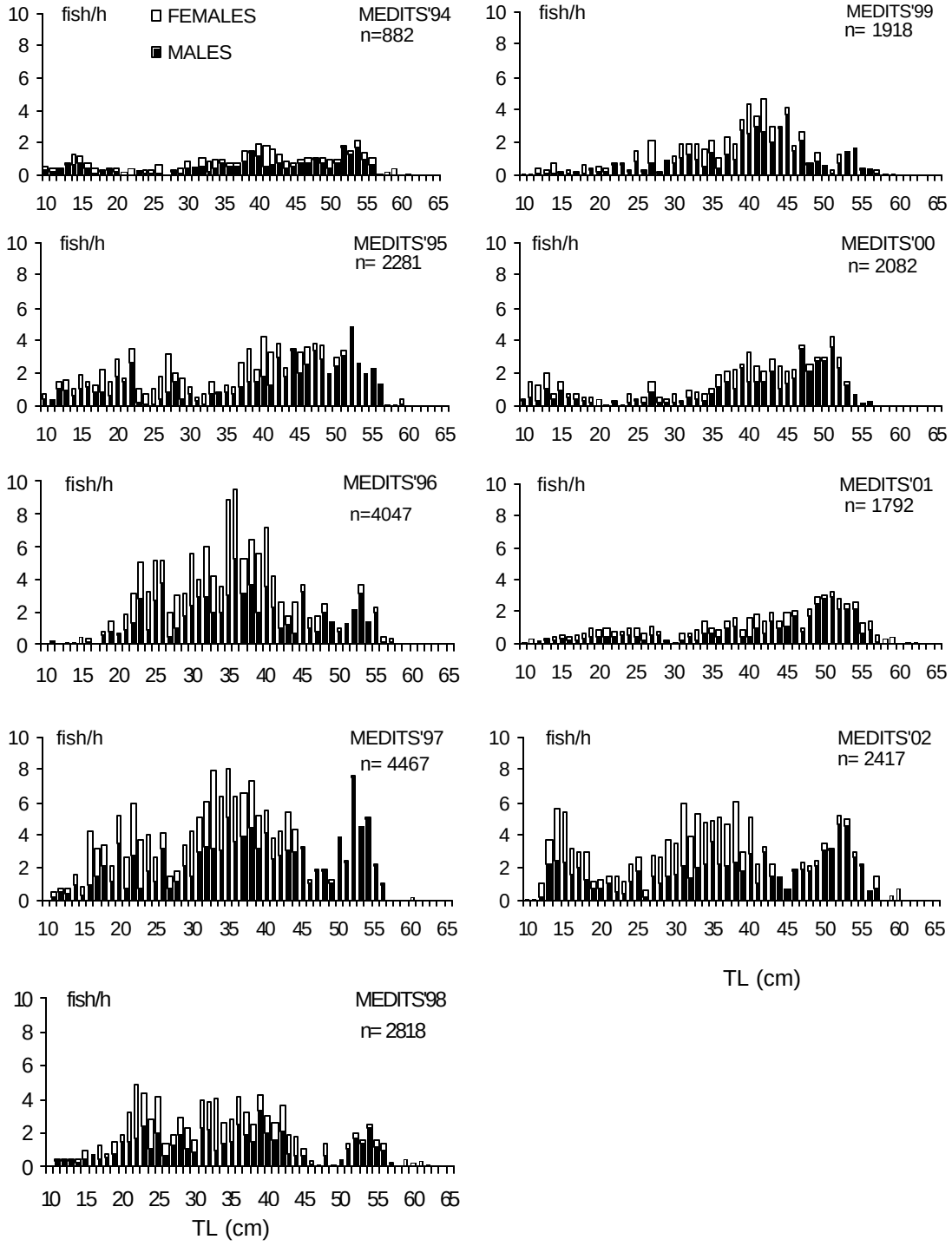

Fig. 4. Length frequency distribution (TL: total length; n: number of specimens measured) by sex (white bars for females and black bars for males) of *Galeus melastomus*, obtained for the whole surveyed area in Alboran Sea during spring MEDITS surveys from 1994 to 2002.

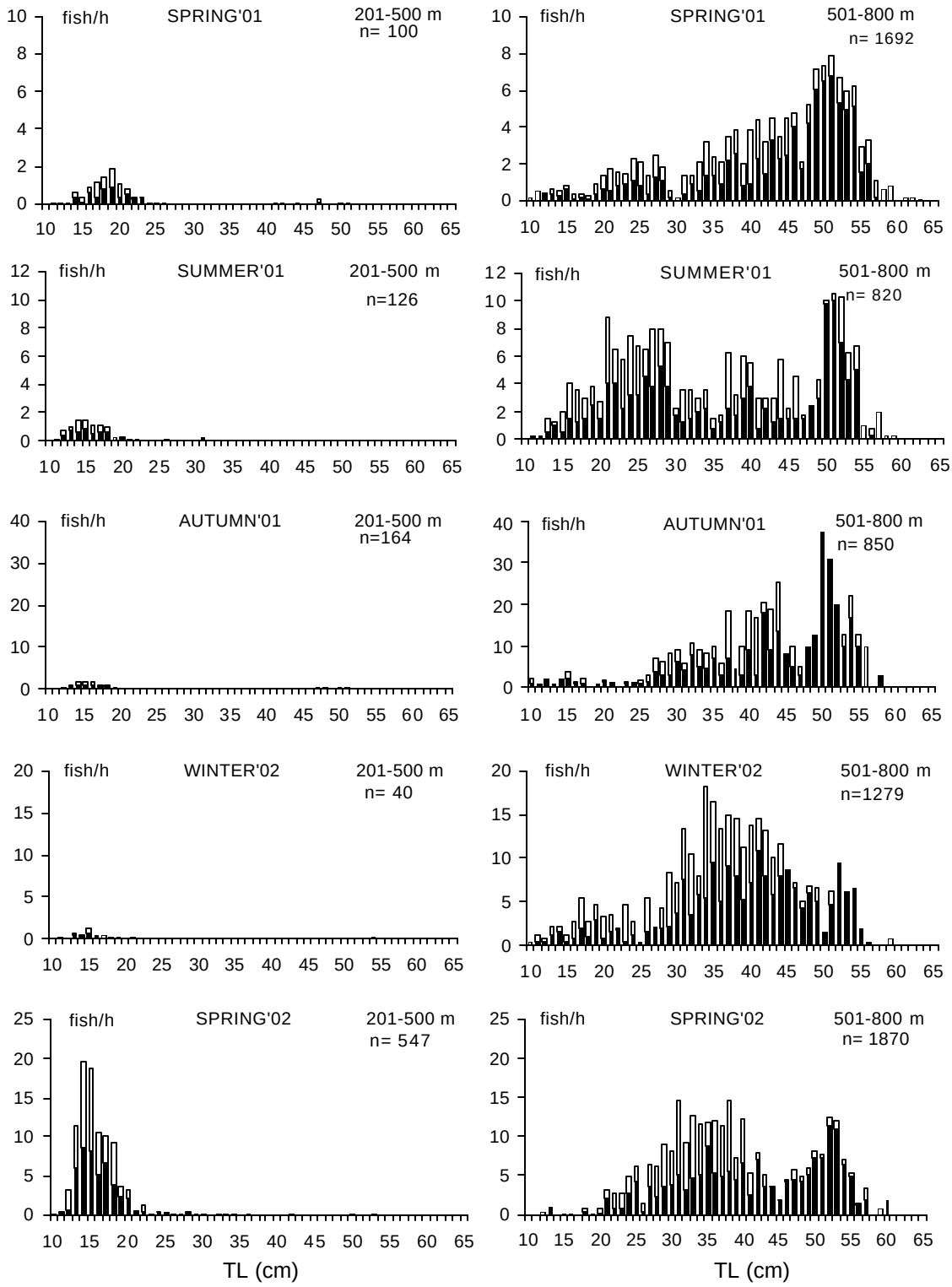

Fig. 5. Seasonal length distribution (TL: total length; n= number of specimens measured) by sex (white bars for females and black bars for males) and depth-strata of *Galeus melastomus*, obtained in Alboran Sea during MEDITS (spring 2001 and 2002) and MERSEL (summer and autumn 2001 and winter 2002) surveys.

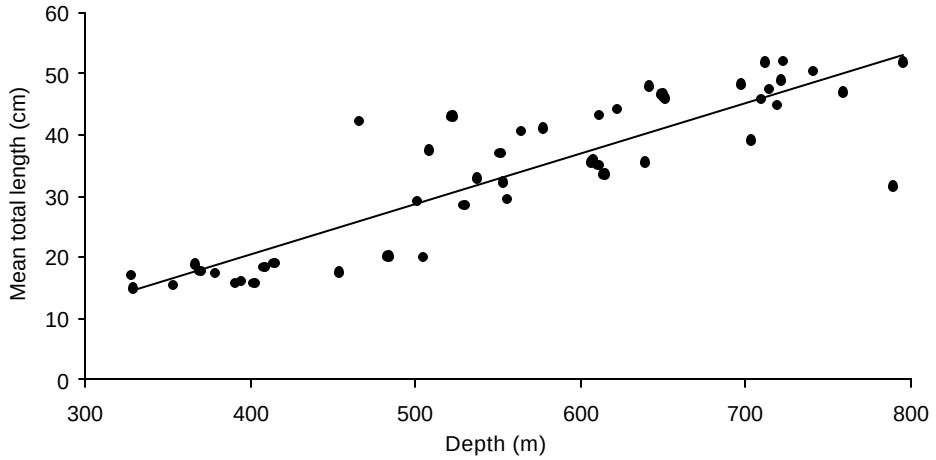

Fig. 6. Relationship between average length of *Galeus melastomus* captured in a sample and sampling depth along the upper slope of Alboran Sea.

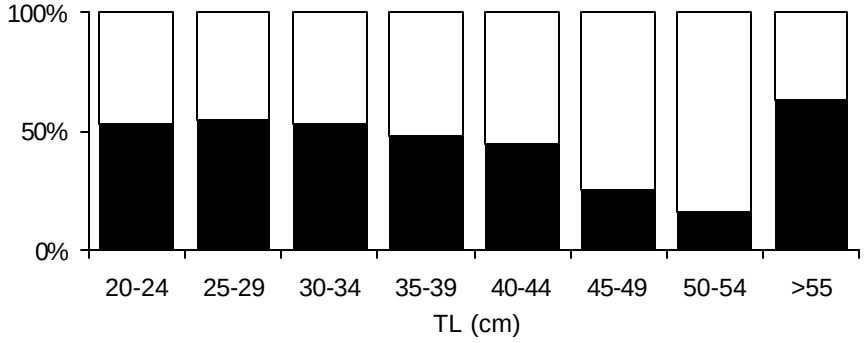

Fig. 7. Proportion of females (black bars) and males (white bars) by 5 cm length-classes of *Galeus melastomus* in the upper slope of Alboran Sea, based on data from 1629 specimens.

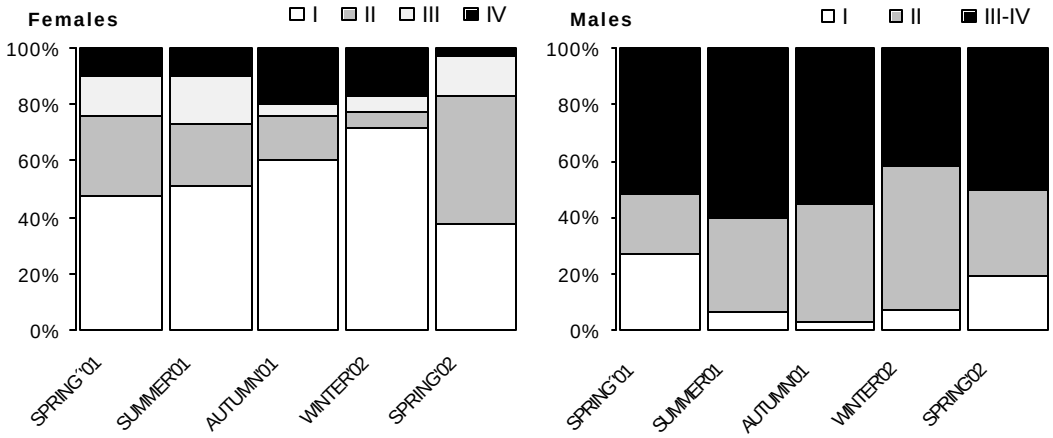

Fig. 8. Seasonal percentage of maturity stages (see Material and Methods for more details) by sex from specimens of *Galeus melastomus* >40 cm in length, obtained along the upper slope of Alboran Sea during MEDITS (spring 2001 and 2002) and MERSEL (summer and autumn 2001 and winter 2002) surveys.