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Elasmobranch Distribution and Assemblages in the Southern Tyrrhenian Sea (Central Mediterranean)

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Abstract

The aim of this study is to identify elasmobranch species present in the SouthernTyrrhenian Sea, to describe their distribution and abundance, to identify significant spatial or temporal differences between species. 14 bottom trawl surveys were carried out from 1994 to 2007. 16 species of elasmobranchs were recorded. Multidimentional Scaling Ordination (MDS) showed two groups according to the depth gradient: in the first one the stations from upper slope and in the second one the stations from middle slope. Mean biomass indices and frequency of occurrence showed that *Galeus melastomus, Etmopterus spinax* and *Scyliorhinus canicula* were the most abundant species. Mean biomass indices for other species were very low. The mean abundance of *G. melastomus* exhibited a positive temporal trend in biomass and density. The mean abundance of *E. spinax* exhibited a negative temporal trend in biomass and in density. For other species abundance varied greatly between years, even if there was no evident trend.

Keywords: Sharks; Ecosystem; Trawl surveys; Multivariate analysis

Introduction

In the Mediterranean Sea there is a high level of exploitation due to a great variety of fishing gears; generally the elasmobranchs are not targeted by commercial fisheries but they are an important by-catch especially of the trawl fishery and deep-water long liners [1-4].

The decreases in abundance and biomass of some elasmobranch species throughout the last decade have been reported in the Gulf of Lions [5,6].

The role of these species as indicators of fishing pressure has been suggested [4,7,8] and management strategies are necessary to minimize significantly the chondrichthyan by-catch.

This paper characterizes the assemblages of demersal elasmobranch on the bottom trawl fishing grounds along the Southern Tyrrhenian Sea. Experimental trawl surveys are analysed for the main species in terms of species composition, community structure and distribution.

This paper could be useful for monitoring future trends in the same area and would allow comparison with other seas.

Materials and Methods

Study area and sampling design

Data here reported come from 14 bottom trawl surveys, carried out during the MEDITS Project, from 1994 to 2007 in the Southern Tyrrhenian Sea. The study area extended from Cape Suvero to Cape S. Vito (Figure 1), within the isobath of 800 metres, for a total area of 7256 km^2. Only 65% (4716 km^2) of the total area studied can be trawled by commercial vessels. The fishing fleet is represented by 80 trawlers providing about 5000 tons of fish, molluscs and crustaceans (IREPA2008).

The bottom of this area is characterized by a narrow continental shelf, sometimes entirely missing and by a steep slope [9]. Sampling procedures were the same in all surveys, according to MEDITS project protocol [10]. Sampling was carried out randomly and the hauls were proportionately distributed in five bathymetric strata: stratum A: 10-50 metres (622 km^2); stratum B: 51-100 metres (1003 km^2); stratum C: 101-200 metres (1224 km^2); stratum D: 201-500 metres (1966 km^2); stratum E: 501-800 metres (2441 km^2). A total of 360 hauls were carried out. An experimental sampling gear with a cod-end mesh size of 20 millimetres 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. The haul length was 30 min in the shelf (10-200 m), and 60 min in the slope (>200 m). All elasmobranch species caught were identified, counted and weighed.

Data processing

Spatial and abundance analyses were employed to investigate temporal trend. In particular, two abundance indexes, mean density index (DI; N/km^2) and mean biomass indices (BI; kg/km^2), were estimated (for each stratum and overall area) according to the swept-area principle [11].

Data were analysed in terms of multivariate analysis using the package Primer v6 [12]. Analyses were carried out on density index. In order to examine the demersal elasmobrach assemblages distribution along space, time and depth, the Multi Dimensional Scaling (MDS) ordination method was employed. The Bray-Curtis similarity index was used on square root transformed data.

The analysis of Similarity (ANOSIM) [13] was applied to detect differences between depths (strata) and time (years). The typifying and discriminating species of the MDS stations were determined using the similarity percentage analysis (SIMPER) [13].

The DI by haul were interpolated and mapped for the three most abundant species. The GIS software ArcMap™ 9.0 (ESRI) was used. An "exact interpolator" (Inverse Distance Weighted) was employed to

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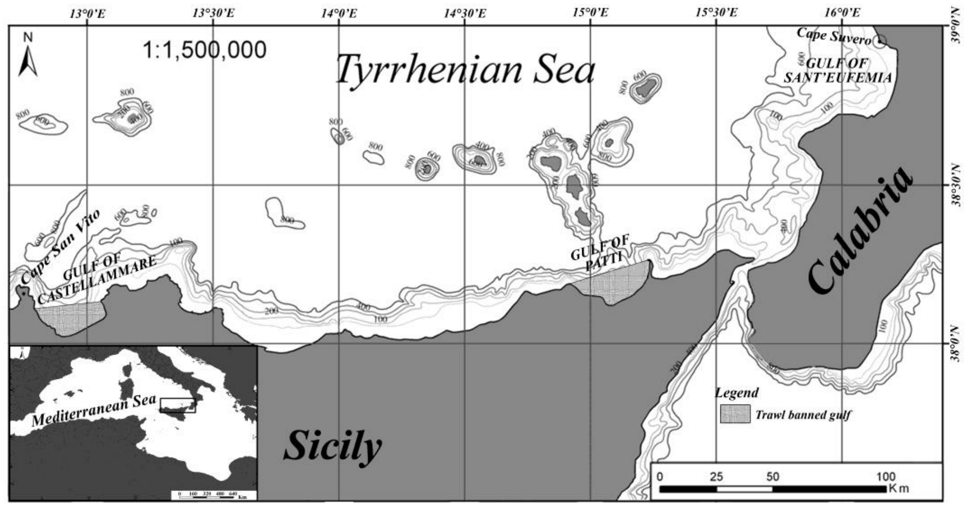

Figure 1: Map of the study area.

Species	Family	Order	Common name
Galeus melastomus Rafinesque, 1810	Scyliorhinidae	Carchariniformes	Blackmouth catshark
Scyliorhinus canicula (Linnaeus, 1758)	Scyliorhinidae	Carchariniformes	Small-spotted catshark
Scyliorhinus stellaris (Linnaeus, 1758)	Scyliorhinidae	Carchariniformes	Nursehound
Squalus acanthias Linnaeus, 1758	Squalidae	Squaliformes	Piked dogfish
Etmopterus spinax (Linnaeus, 1758)	Etmopteridae	Squaliformes	Velvet belly
Dalatias licha (Bonnaterre, 1788)	Dalatiidae	Squaliformes	Kitefin shark
Dasyatis pastinaca (Linnaeus, 1758)	Dasyatidae	Rajiformes	Common stingray
Pteroplatytrygon violacea (Bonaparte, 1832)	Dasyatidae	Rajiformes	Pelagic stingray
Myliobatis aquila (Linnaeus, 1758)	Myliobatidae	Rajiformes	Common eagle ray
Dipturus oxyrinchus (Linnaeus, 1758)	Rajidae	Rajiformes	Longnosed skate
Raja clavata Linnaeus, 1758	Rajidae	Rajiformes	Thornback ray
Raja miraletus Linnaeus, 1758	Rajidae	Rajiformes	Brown ray
Raja montagui Fowler, 1910	Rajidae	Rajiformes	Spotted ray
Raja polystigma Regan, 1923	Rajidae	Rajiformes	Speckled ray
Torpedo marmorata Risso, 1810	Torpedinidae	Torpenidiformes	Spotted torpedo
Torpedo torpedo (Linnaeus, 1758)	Torpedinidae	Torpenidiformes	Common torpedo

Table 1: Elasmobranch species identified in the Southern Tyrrhenian Sea during the Medit project from 1994 to 2007.

		Species	Av. abundance	Av. Similarity	sim/SD	
D stratum: 201 - 500 m	Av. Similarity: 48.75	*Galeus melastomus*	3.1	32.24	1.34	
		Scyliorhinus canicula	1.78	13.2	0.81	
E stratum: 501 - 800 m	Av. Similarity: 72.36	*Galeus melastomus*	3.28	40.95	2.62	
		Etmopterus spinax	2.41	30.68	2.28	
		Species	D stratum Average abundance	E stratum	Av. dissimilarity	Diss/SD
D stratum: 201 - 500 m vs E stratum: 501-800 m	Av. Dissimilarity: 56.6	*Etmopterus spinax*	0.21	2.41	17.68	2.17
		Galeus melastomus	3.1	3.28	13.64	1.28
		Scyliorhinus canicula	1.78	0.38	13.26	1.27
		Scyliorhinus stellaris	0.75	0.08	6.21	0.54
		Torpedo marmorata	0.46	0	3.8	0.54

Table 2: SIMPER analysis results.

render back the real value in every sample site of the studied area [14]. Mean distribution maps were produced pooling the records of surveys from 1994 to 2007.

The correlation between DI and BI values and years was tested using the Spearman's rank-order correlation (ρ).

The distribution of elasmobranches in relation to depth was analyzed comparing the density index by Kruskal–Wallis test.

Results

16 elasmobrach species were recorded (Table 1). The orders

observed were: Rajiformes (8 species), Squaliformes (3 species), Carcharhiniformes (3 species) and Torpediniformes (2 species).

MDS ordination (Figure 2) showed the stations reporting the stratum. Two main groups were distinguished: in the first one the stations from upper slope (201-500 metres) and in the second one the stations from middle slope (501-800 metres) (ANOSIM test: Global R=0.6; p<0.01).

To individuate the importance of time in order to discriminate the assemblages one-way ANOSIM tests were performed for "year" factor across all "stratum" groups respectively. Each depth stratum was treated separately. There were no differences, across "stratum" groups and between "year" groups (Global R: 0.182 p>0.05).

The results of the SIMPER analysis highlighted the species that mainly contribute as a percentage to similarity within groups "stratum" (Table 2). *Galeus melastomus* and *Scyliorhinus canicula* were important in typifying the demersal fish community of D stratum (201-500 m). The analysis performed on E stratum (501-800 m) showed that, although *G. melastomus* was still present, *Etmopterus spinax* also contributed to typifying the group.

SIMPER analysis indicates dissimilarity between assemblages (average dissimilarity: 56.6). The pool of species responsible for discriminating these groups was mainly constituted by *E. spinax*, *G. melastomus* and *S. canicula*.

In Figure 3 distribution is shown of the three most abundant elasmobranch species in the Southern Tyrrhenian Sea over 14 years. *G. melastomus* and *E. spinax* are more abundant in the eastern and western part of the study area, specifically outside the Gulf of *S. Eufemia* and in the areas bordering the Gulf of Castellammare; these species were also abundant in an area localized between Sicily and Calabria, in correspondence with the Strait of Messina. *G. melastomus* and *E. spinax* were also present inside and outside the Gulf of Patti respectively.

S. canicula was more equally distributed in the study area and like the other two species, was particularly present outside the Strait of Messina.

The mean abundance of *G. melastomus* exhibited a positive temporal trend in biomass and density (Spearman ρ: 0.543, p<0.05 and ρ: 0.587, p<0.05 respectively). Instead the mean abundance of *E. spinax* exhibited a negative temporal trend in biomass (Spearman ρ: -0.565, p<0.05) and in density (Spearman ρ: -0.661, p<0.05). For other species, abundance varied greatly between years (Figure 4).

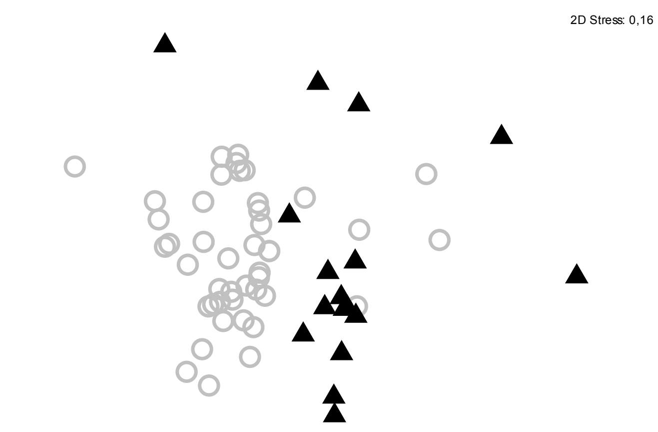

Figure 2: Non-metric Multidimentional Scaling Ordination (MDS) of the sampling stations according to depth. Triangles are the hauls in the upper slope (200 – 500 metres); circles are the hauls in the middle slope (500 – 800 metres).

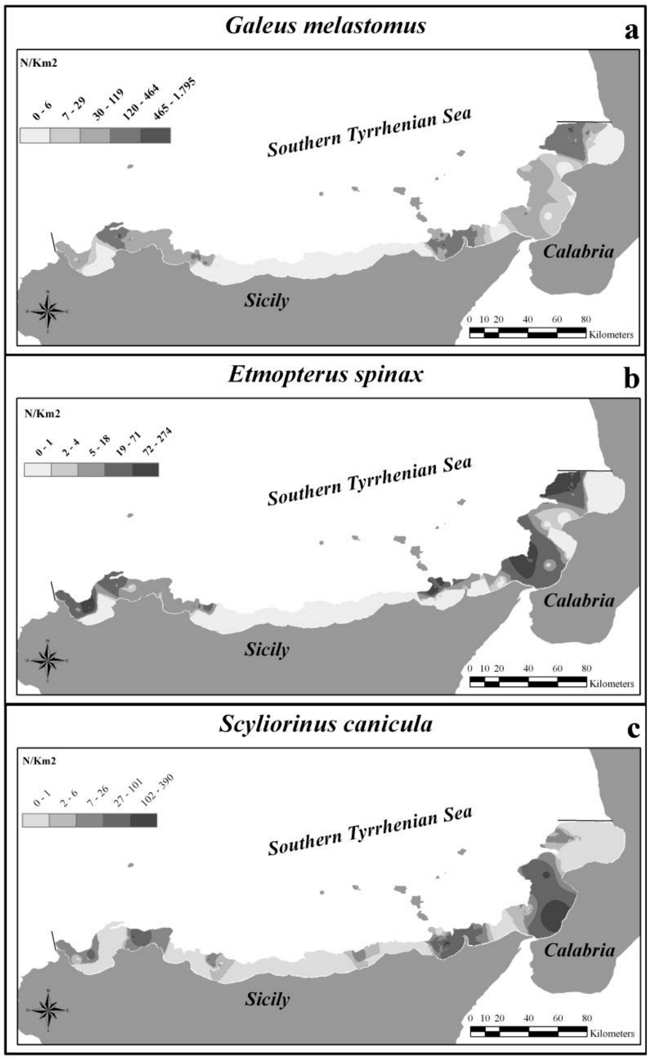

Figure 3: Distribution of (a) *Galeus melastomus*, (b) *Etmopterus spinax*, and (c) *Scyliorinus canicula* along the Southern Tyrrhenian Sea over 14 years.

Abundance appeared to be greatest for *G. melastomus* deeper than 400 m, for *E. spinax* deeper than 450 m and for *S. canicula* at 300-450 m. However, differences in abundance were statistically significant only for *G. melastomus* (Kruskal Wallis H: 36.1, p<0.01). and *E. spinax* (Kruskal Wallis H: 57.1, p<0.01). In comparison *S. canicula* was more evenly distributed with respect to depth (Kruskal Wallis H: 14.7, p>0.05) (Figure 5).

Discussion

The analysis of demersal elasmobranch species in the Southern Tyrrhenian Sea has shown that demersal elasmobranch assemblages are aligned with depth. These results are similar to those obtained in the Atlantic Ocean [15] and in the Western Mediterranean [16] The most important boundary, located around 500 m, separates the species of the upper slope from those of the middle slope down to 800 m. The bathymetric boundaries are similar with those obtained in previous

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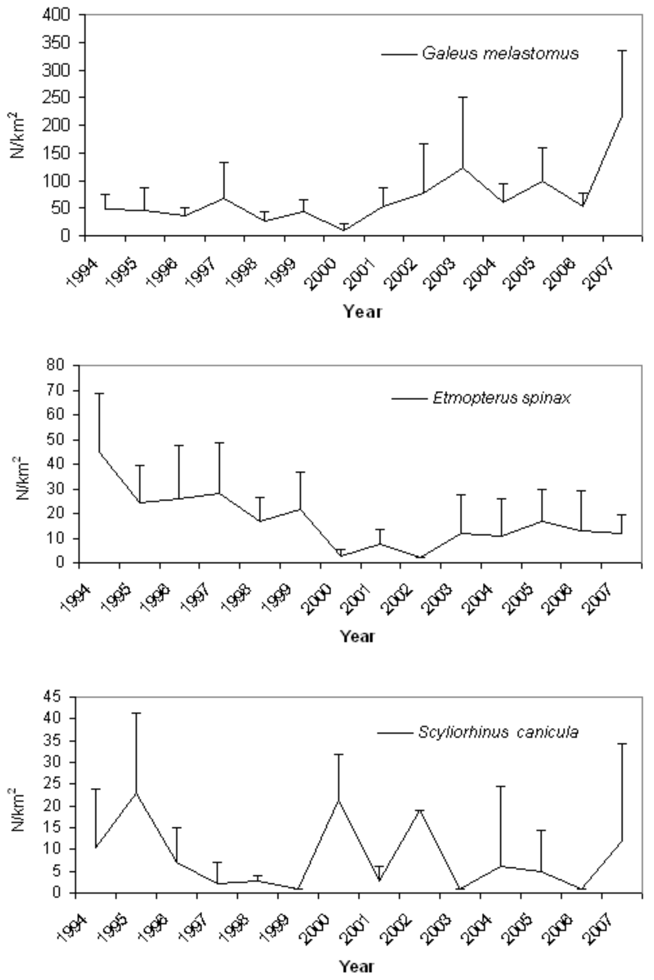

Figure 4: Mean abundance (N/km2) and standard error of the most abundant species from the trawl surveys of 1994-2007.

studies of demersal assemblages carried out in the Southern Aegean [17] and North West Mediterranean [18]. Data reported here suggests that the structure of assemblages does not change in over a period of 14 years.

The upper slope assemblage is characterised by *G. melastomus* and *S. canicula*. The middle slope assemblage is characterised also by *G. melastomus*, a species with a wide depth range, and *E. spinax*, a species present only in this assemblage.

Some papers on slope assemblages demonstrate the importance of factors associated to depth rather than depth itself to affect the assemblages structure [19-21]. The depth in fact, may affect other environmental factors, both biological (trophic factors, interspecific competition, predator-prey relationship) and physical (steepness of the continental slope, substrate type, hydrographic condition, dissolved oxygen, light intensity) [22-24]. Recently, shark assemblages changes, related to temperature and salinity modifications of deep-water masses, have been also reported [25].

The significant increase in density and biomass indices shown by *G. melastomus* has already been reported for the species in the South of Sicily [26,27].

The opposite abundance temporal trends shown by *G. melastomus* and *E. spinax* could be explained by comparing their life history traits. *Galeus melastomus* is a multiple oviparous whereas *Etmopterus spinax is* a ovoviviparous. The study of length at first maturity has revealed that *E. spinax* is a late-maturing species [28] and this fact makes these species more vulnerable to exploitation. Also, they do not have the same "catchability" to trawl fishing. The size distribution varies with depth for both species with larger specimens occurring at deeper waters and the smaller ones at shallower waters [16,26,29]. Moreover, the wider vertical distribution of *G. melastomus* (lower than 1000 m) might mitigate the fishing pressure as the species lives beyond the usual deepest commercial trawling limit [26,27]. *G. melastomus* shows an increasing abundance in the Southern Tyrrhenian Sea despite the persistent trawling activities [30].

Cartilaginous fish represent a good fraction (about one third) of the by-catch of red-shrimp fishing in the South of Sicily. The most common species are *G. melastomus* and *E. spinax* which are caught in over 90% of the hauls [31]. Generally they are discarded immediately after capture but elasmobranchs may die after capture because of the sudden pressure changes and handling on board [32,33]. We can hypothesize that *E. spinax* may be more sensitive to these events than *G. melastomus*.

Nevertheless, factors such as competition, changes in oceanographic conditions and changes in food abundance could affect species abundance.

There is lack of studies about distribution and structure of fish

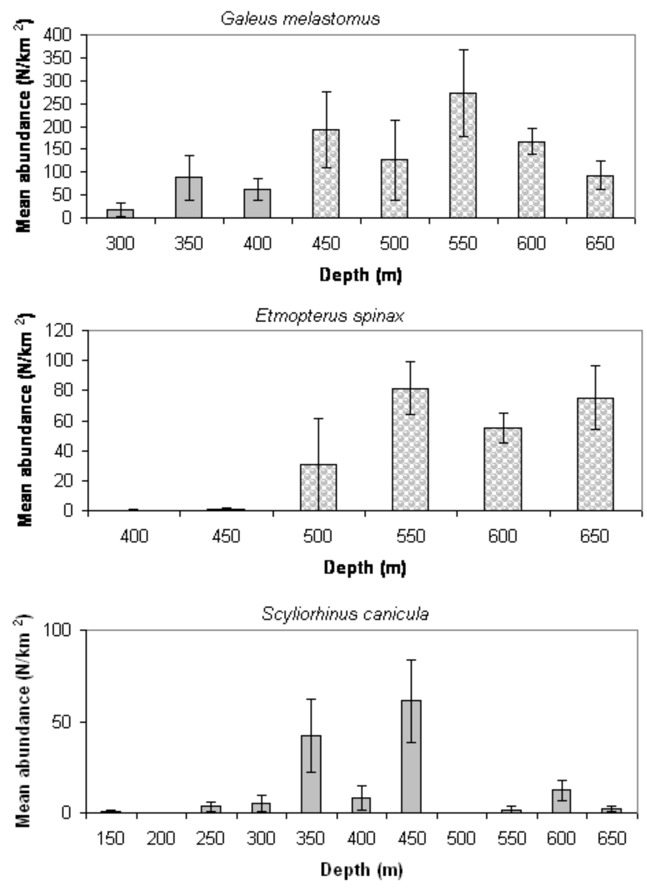

Figure 5: Mean abundance (N/km^2) and standard error for the most abundant species in each depth interval in the Southern Tyrrhenian Sea from the trawl surveys of 1994-2007.

communities in a long temporal scale in most of Mediterranean regions; such studies are necessary for ecosystem based management. We argue that results here reported could be useful as basis for management of fishery activities in the Tyrrhenian Sea.

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