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# Cartilaginous Fishes as a Component of Trawl Discard in Strait of Sicily

(Elasmobranch Fisheries – Oral)

by

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## Abstract

During 1995-1999 period cartilaginous fishes catch component of trawl fishery was studied in Strait of Sicily. A total of 276 hauls were conducted in three zones of the Strait. In the north zone, comprising the area near Capo Bon, and in the south zone, located below the Pelagian Islands, 1995 data on elasmobranch biomass abundance and on its discard and commercial fractions were collected. In the Porto Palo zone, placed in the waters of SE Sicily, the availability of five years (1995-1999) data on effort and catches made also possible the evaluation of CPUE time variation per species. Due to the wide fishing bathymetrical range explored, distribution with depth of the twenty-six species of cartilaginous fishes recognised, was studied in the three zones. Biodiversity and biomass abundance of elasmobranchs resulted high in the north zone while low in the south zones and in the Porto Palo zone. This last was probably overexploited according to total catch amount and to declining CPUE values for several cartilaginous fishes species.

## Introduction

Professional otter trawl fishing produces a considerable amount of by-catch, part of which is represented by remarkable quantity of several cartilaginous fishes species (Bonfil, 1994, Branstetter 1993; Casey *et al*., 1998). The majority of them are completely discarded for their low economical value and only few species are partially commercialised (Notarbartolo *et al*., 1998; Vacchi *et al*., 2000). In the Strait of Sicily cartilaginous fishes by-catch is associated principally to red shrimps fisheries, representing one third of the accompanying species (Ragonese et al., 2000) but also coastal otter trawl fisheries affect seriously shallower sharks and mostly skates populations (Bertrand et al., 2000; Relini *et al.,* 2000). In this study an attempt is made to define which elasmobranch species are present in three distinct zones of the Strait of Sicily, their abundance, bathymetrical distribution and, in one of such zones, to evaluate the effect of fishing on several cartilaginous species in terms of CPUE and commercial and discard fractions in a five years period. Due to their peculiar biological features such as slow growth and delayed maturation, low fecundity and long reproductive cycles (Castro *et al.,* 1999), the majority of elasmobranchs are unable for their stocks to recover from overfishing. The risk of irreversible loss of biodiversity and of environmental damages on trophic chains is nowadays palpable so much as the need of biological kwnoledge and fisheries data about elasmobranchs.

## Materials and Methods

During 1995-1999 period, a total of 276 hauls were conducted in three zones (A, B and C as shown in Fig. 1) of the Strait of Sicily by means of professional otter trawl vessels of Mazara and Porto Palo fisheries. The northern zone A comprised the area near Capo Bon, the southern zone B is located below the Pelagian Islands and the eastern zone C is placed in the waters of SE Sicily within Porto Palo harbour and Malta Island. Zone C was separated into three further subzones (1, 2 and 3 in Fig. 2) according to a bathymetrical criterion. In Table 1 number of hauls and bathymetrical ranges are reported for zones A and B in 1995. In Table 2 same details of the three subzones of zone C are shown by year in the time series 1995-1999. Data were collected on board by scientific personnel who performed species identification, discard and commercial fractions weighing per species and fishing data recording (position, depth and hauls duration). Percentages of biomass abundance were calculated as weight proportion of each species with respect to the total weight of the species present by zone or by bathymetrical range. Due to the little vertical variation of bottoms in zone B, bathymetrical distribution of elasmobranchs was not considered in such zone. CPUE were expressed as grams of cartilaginous species caught per hour of fishing per haul. Commercial and discard fractions were expressed as percentages in weight by total for each species caught. One way Anova Test was used in testing difference among mean haul durations per year in the time series 1995-1999 in zone C (Table 4) and among mean catches per haul of zones A, B and C. Two-way Anova Test was used in testing difference among mean haul durations per year per subzone 1, 2 and 3 of zone C in the time series 1995-1999. All tests were performed by using STATISTICA Package

**Results**

Cartilaginous fishes weigth percentages of abundance in zones A, B and C are shown in Fig. 3, 4 and 5 respectively. In zone A biodiversity resulted to be the highest with 21 species of 8 families. *R. oxyrhincus* (26%), *S. canicula* (20%) and *S. acanthias* (17%) represent more than the half of total catches. In zone B only seven species belonging to four families were recognised and *S. acanthias* (34%) and *R. asterias* (28%) are the more abundant. In zone C twelve species of six families were found with *M. mustelus* (35%) and *T. torpedo* (13%) representing near the half of total biomass. As concern the three subzones of zone C, *M. mustelus* (42.97%), *T. marmorata* (26.43%) and *G. melastomus* (49.23%) are respectively the principal species in terms of biomass in subzones 1, 2 and 3 (Fig. 6,7 and 8, respectively). Absolute amount of elasmobranch catch and standardized values per zone are reported in Table 3. In terms of abundance zone A is the most productive either as absolute values and as standardized. Yields of zones B and C expressed as standardized values are strongly smaller than of zone A, with that of zone C the smallest, being about the half of B. One-way Anova Test: $F(2,272)= 2.58$ $p< 0.001$.In Fig. 9 relative biomass abundances per bathymetric stratum in zone A are shown for Scyliorhinidae (a), Squalidae (b), Rajidae (c and e) and (absolute biomass abundance) for *Chimaera monstruosa* (d). *S. canicula* and *S. stellaris* biomass decreases with depth while *G. melastomus* increases (Fig 9a). A similar pattern of depth distribution can be observed among Squalidae (Fig 9b). From coastal to deeper waters *S. acanthias* biomass decreases, *S. blainvillei* is found in little amount within 400-600 metres depth and *E. spinax* is dominant in the deepest stratum. As concern Rajidae (Fig 9c) *R. asterias*, *R. clavata* and *R. oxyrhincus* are the main species. The first two are coastal representing both about 30% of total biomass in the shallowest stratum and then decreasing with depth. *R. oxyrhincus*, starting from 30% in 200-300 metres stratum, become prevailing in the deepest one. The other raijids species were caught in a scarce amount and not continuously throughout all depth range (Fig 9e): *R. melitensis* and *R. polystigma* resulted to be present in the shallowest stratum and *R. naevus* in 400-500 metres stratum only. *R. montagui* was found in the first two strata (200-400 metres depth) and *R. miraletus* in all strata except in 400-500 metres depth, with a biomass peak in 300-400 metres depth. Biomass peak for *Chimaera monstruosa* occurs in 400-500 metres depth (Fig. 9d).

Concerning zone C, bathymetrical distribution of Scyliorhinidae (Fig. 10d) resembles to that of zone A as also Rajidae except for differing in smaller number of species and for consistent presence of *R. miraletus* in the deepest stratum (Fig. 10c). About other squaliformes *M. mustelus* and *C. granulosus* were found only in 100-150 and in 150-250 metres depth respectively while *S. blainvillei* within 150-300 metres depth (Fig 10a). As regards Torpedinidae *T. marmorata* is prevalent with a biomass peak in 200-250 metres depth and *T. torpedo* presents two biomass peaks in both shallowest and deepest strata of zone C (Fig. 10b).

Effort trend in the time series 1995-1999 of zone C is shown in Fig. 11. Total hours of fishing by year has been augmenting especially for subzone 3 (e.g. from 4 hs in 1995 to about 48 in 1999), second for subzone 1 (e.g. from about 23 hs in 1995 to about 52 in 1999) and less in subzone 2 (e.g. from about 12 hs in 1995 to about 27 hs in 1999). In total effort in zone C has been increasing from about 38 hs in 1995 to 187 hs in 1999. Mean values of hauls duration confirm increasing effort trends in subzone 1 and in all zone C in the period 1995-1999 (Table 4). Two-way Anova Test: $F(8, 143)=2.58$ $p< 0.05$; One-way Anova Test: $F(4; 153)=8.77$ $p<0.001$).

CPUE variation per species of zone C in time series 1995-1999 are shown in Fig. 12. CPUE values of *T. marmorata* and *G. melastomus* has been declining in all subzones (Fig 12a and 12d, respectively). *S. canicula* CPUE has been declining in subzone 2 and 3 (Fig 12c) while *T. torpedo* values has been increasing in subzone 1 (Fig. 12b). In the same subzone CPUE values of *R. asterias* (Fig. 13a) declined while those of *M. mustelus* and of *R. clavata* increased in the last three years of the period (Fig. 13c and 13d, respectively). In subzone 2 *R. miraletus* values generally increased (Fig. 13b).

Discard and commercial fractions per species for zones A+B and zone C are shown in Fig. 14 and 15, respectively. In zones A and B commercial species are represented by *S. acanthias* (around 100% of total catches), *R. clavata* (around 95%) and *R. montagui* (around 90%). Partially commercial species are *S. canicula* (around 70%), *R. asterias* and *S. blainvillei* (both around 50%). Occasionally commercial species are *R. miraletus* (around 30%), *S. stellaris* (around 9%) and *R. oxyrhincus* (around only 3%). All other species are completely discarded.

In zone C *R. asterias, R. clavata, M. mustelus, D. pastinaca* and *C. granulosus* are fully commercialised while *S. stellaris*, *T. torpedo*, *S. blainvillei* and *G. melastomus* are totally discarded. *S. canicula* is parially traded species (around 70%) while occasional are *R. miraletus* (around more than 25%) and *T marmorata* (around only 4%).

## Discussion

In total twenty- five species belonging to nine families of elasmobranchs were found in the three zones of the Strait of Sicily. Considering that literature reports about 70 cartilaginous fishes species, pelagic included, present in Mediterranean Sea (Fischer et al., 1987; Capapè, 1989; Fredy and Maurin, 1987; Notarbartolo et al., 1998) and 44 demersal species (Relini et al., 2000), the trawled bottoms of the sampled zones, mostly zone A, appear to be rich in terms of elasmobranch biodiversity. In the bathyal stratum of Strait of Sicily Ragonese in 1993 found a smaller number of species (20) but the difference could be due principally to some coastal species of Rajidae not distributed on red shrimps bottoms. On the contrary *H. griseus*, *M.asterias*, *C. uyato*, *D. licha*, *R. fullonica* and *R. alba* were not caught in our sampling. Zone A appear to show the highest biodiversity with respect to zones B and C. In fact some recognised species become very rare in Italian waters, such as *Oxynotus centrina*, *S. squatina*, *S. aculeata*, *T. nobiliana* (Arena *et. al*., 1973) and some endemic Rajidae such as *R. polystigma*, *R. melitensis* and *R. naevus.* In zone A biomasses of *R. oxyrhincus*, *S. canicula* and *S. acanthias* represent more than the half of total catches and this result is in agreement with other works in the all area of Strait of Sicily (Ragonese *et. al*., 2000; Relini et al., 2000). Bathymetrical distribution of Scyliorhinidae, Squalidae and of main species of Rajidae in zone A is very similar to that reported in literature for mediterranean elasmobranchs (Fischer *et al*., 1987). Among Scyliorhinidae *S. canicula* is coastal, *S. stellaris* is found in scarce amount within 300-500 metres depth range while *G. melastomus* is tipical mesobathyal species. *S. acanthias*, *S. blainvillei* and *E. spinax* present a Scyliorhinidae-like pattern of distribution and partially overlap in 400-500 metres depth range. *R. oxyrhinchus R. asterias* and *R. clavata* overlap in the shallower stratum but *R. oxyrhinchus* become prevailing with the depth increase. The other raiids species were caught in scarce amount and few considerations can be argued about. *R. polystigma* and *R. melitensis* are considered species endemic of waters around Malta Island (Fredj *et al*., 1987). *R. montagui* and *R. naevus* are little known and identification misleading are frequent by cause of taxonomic confusion (Ragonese *et. al*., 2000). *R. miraletus*, thought quite common in other Mediterranean areas (Fischer *et al*., 1987), resulted scarce in zone A and principally fished in 300-400 metres stratum. As other rajids, this species is strongly dependent by nature of substratum, preferring sandy bottoms (Tortonese, 1956). The presence of *Chimaera monstruosa*, the unique mediterranean rabbit fish, and its biomass peak in 400-500 stratum confirm observation in litterature (Arena, 1985). Diversely from zone A, zones B and C show low biodiversity with scarce abundances as expressed by mean catch per haul in the three zones (Table 3). This strong difference could be due to favourable environmental factors of zone A as heterogeneity of bottom morphology but also to the effect of fishing. In zone B the only 7 present species are typical of coastal-shelf environment and *S. acanthias* and *R. asterias* are the main species. The presence of the deep skate *R. oxyrhincus* owed to catches occurred in the lower limit (300 metres) of the considered bathymetrical stratum. Species composition in zone C is richer than B in terms of number with 12 recognised species, but it is the less productive with the smallest value of mean catch per haul (Table 3). From coastal waters (subzone 1) to deep bottoms (subzone 3) species composition changes gradually. It can be observed as Torpedinidae and *M. mustelus* represent a large part of total biomass of subzone 1 while Scyliorhinidae, especially *G. melastomus*, increase in abundance with depth, representing near three fourth of total biomass in subzone 3. This bathymetrical species composition pattern is confirmed by MEDITS and GRUND data (Bertrand *et al*., 2000; Relini *et al*., 2000). Depth distribution of Scyliorhinidae is very similar to that already discussed for zone A as also distribution of Rajidae, except for exclusive presence of *R. miraletus* in 150-300 metres stratum. *C. granulosus* and *S. acanthias* overlap in 150-200 but the latter is unique Squalidae in 200- 300 metres stratum of the zone C. Torpedinidae show a peculiar depth distribution with *T. torpedo* biomass peaking in the shallowest and deepest strata and *T. marmorata* biomass peaking in 150-200 metres depth. The two congeneric species inhabit the same bottom environment but differ in reproductive cycle and circadian activity (Tortonese, 1956). Such features could reflect in this depth distribution.

In the period 1995-1999 total effort in zone C has been progressively increasing. The major contribute was given by the increase of hours of fishing in subzone 3 and partially by increase in other two zones. Mean hauls duration in zone C has also been expanding mainly for the contribute given by subzone 1 while mean haul durations of the subzones 2 and 3 remain about constant in 1995-1999 period. It means that in entire zone C the number of hauls and the mean haul duration increased both, in subzone 3 number of hauls augmented only, in subzone 1 the number of hauls decreases and in subzone 2 the situation stayed stable. CPUE values of *T. marmorata, G. melastomus*, *S. canicula* and less *R. asterias* has collapsed in all subzones being around zero in subzone 3, or rapidly dcreasing in subzone 1 and 2. On the contrary CPUE values of *T. torpedo, R. clavata, M. mustelus* increased in subzone 1 and that of *R. miraletus* in subzone 2. GRU.N.D. data for the Strait of Sicily show for *G. melastomus, S. canicula, R. miraletus* and *M. mustelus* a fluctuation of CPUE and a slight decrease for *T. marmorata, R. asterias* and *R. clavata* in 1985-1998 period (Relini *et. al*., 2000). Similar fluctuating CPUE are achieved during MEDITS 1994-1998 trawl survey for *R. clavata, R. miraletus, G. melastomus* and *S. canicula* (Bertrand *et. al*., 2000). A comparison among our data and MEDITS and GRU.N.D. data show how in a short time range increasing and declining CPUE trend could occur in elasmobranch population but in a long period the values seems to fluctuate. Furthermore, MEDITS and GRU.N.D. trawl surveys were random stratified sampling and they evaluate status of the stocks not only in zones interested by otter trawl fishing. All these observation taken together are evidence of interactions between overfished areas and unfished areas within species and among partially or totally depth overlapped competitive species. In our data the rising of CPUE for *R. clavata, M. mustelus* and *R. miraletus* occurred in 1997 when CPUE for *G. melastomus*, *S. canicula* and *R. asterias* fault down. Identically CPUE of *T. torpedo* rise in 1996 when that of *T. marmorata* collapsed.

In zones A and B only three species were fully commercialised. *S. acanthias* is a known appreciated shark species in Mediterranean Sea (Fischer *et al*., 1987) and more *R. clavata* (Bini, 1967). The same can be referred of *R. asterias*, *S.canicula* and *S. blainvillei* but in this case fishermen use to select bigger sized individual for trade (Vacchi *et al*., 2000). All other species of the zones are discarded or occasionally commercialised in a scarce amount. The total discard fraction represent 56.7% of the all catches while 43.3% the commercial fraction. In zone C five species are fully commercialised. *R. clavata*, *R. asterias* and *M.mustelus* are the traditional commercialised mediterranean elasasmobranchs (Fischer et al., 1987; Bini, 1967; Tortonese, 1956) for the high value of their meat; the last two species are unusually *D. pastinaca* and *C. granulosus* which are not considered of economical value, except bigger sized individuals and are sold at a very cheap price. Local customs and preferences can determine the choice in trading elasmobranchs (Vacchi *et al*., 2000). Also bigger individuals of *S.canicula*, as in zones A and B, are sold. The total discard fraction of zone C represent 50.9% of the all catches while 49.1% the commercial fraction. Due to such similar percentages in zone A, B, and C, we can conclude that in Strait of Sicily about more of the half of fished elasmobranchs is discarded and the rest is commercialised.

In conclusion result of this study underline either the high biodiversity found in the North-Western zone of the Strait of Sicily and also the presence of overfished zone in South-Eastern. Commercialisation of elasmobranch species must be optimized, being half of the catches totally discarded. Natural replacement of the fished cartilaginous species, interspecific relationships, and biological data are well beyond to be entirely understood and fisheries accurate data and stocks conservation program are needed to avoid stocks depletion or even eradication of some elasmobranch species.

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**Table 1.** Number of hauls carried out in zones A and B per bathymetrical stratum during 1995.

| N° of hauls x zone | Bathymetrical range | | | |
|---|---|---|---|---|
| | 200-300 | 300-400 | 400-500 | 500-600 |
| A | 29 | 31 | 33 | 12 |
| B | 13 | \ | \ | \ |

**Table 2.** Number of hauls carried out in zone C per bathymetrical subzones during 1995-1999 period.

| Zone C | | Subzone | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | |
| | **Depth range** | 100-150 | 150-200 | 200-300 | **TOT x year** |
| **YEAR** | **1995** | 11 | 3 | 1 | 15 |
| | **1996** | 23 | 13 | 4 | 40 |
| | **1997** | 17 | 11 | 5 | 33 |
| | **1998** | 18 | 14 | 5 | 37 |
| | **1999** | 15 | 7 | 11 | 33 |
| | **TOT x zone** | 84 | 48 | 26 | **Tot. =158** |

**Table 3.** Total elasmobranch catches in Kg., total number of hauls and mean catches per haul in zone A, B and C.

| Zone | Total catches (Kg) | Total hauls | Catch /hauls |
|---|---|---|---|
| **A** | 462.75 | 105 | 4.41 |
| **B** | 6.98 | 13 | 0.54 |
| **C** | 41.1 | 158 | 0.26 |

**Table 4.** Mean duration per haul in subzones 1, 2 and 3 and in all zone C in the time series 1995-1999.

| | 1 | 2 | 3 | All subzones |
|---|---|---|---|---|
| **1995** | 2.06 | 3.90 | 4.00 | 2.55 |
| **1996** | 2.25 | 3.84 | 4.38 | 2.98 |
| **1997** | 2.96 | 3.86 | 4.45 | 3.48 |
| **1998** | 3.43 | 4.10 | 4.08 | 3.77 |
| **1999** | 3.46 | 3.88 | 4.36 | 5.65 |

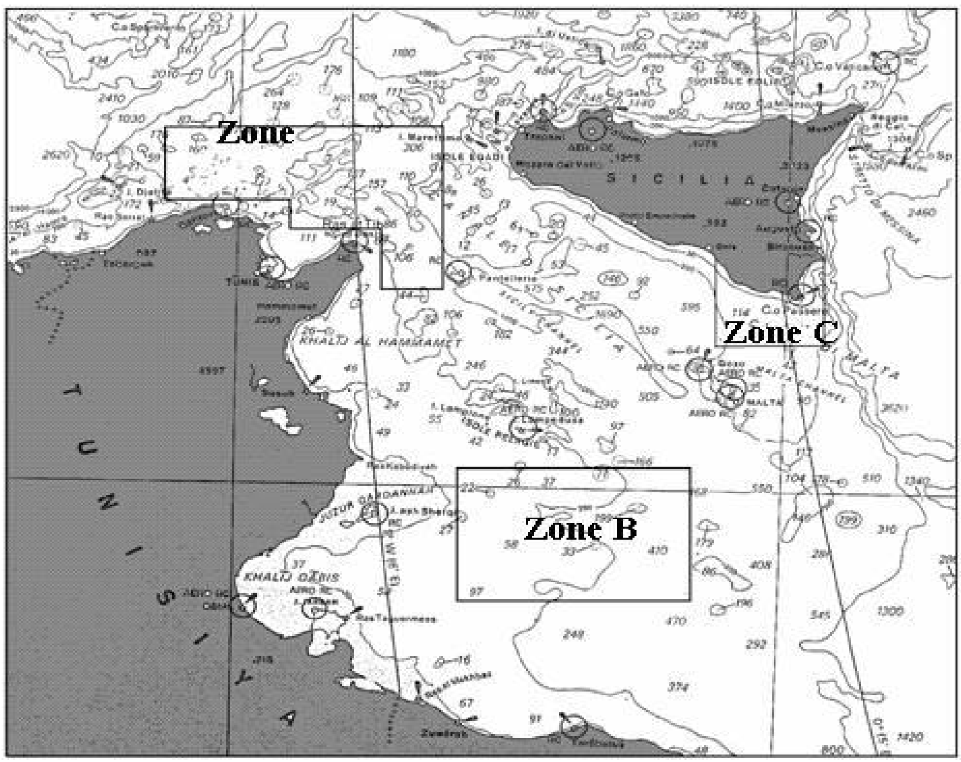


Fig. 1. Sampling zones in the Strait of Sicily

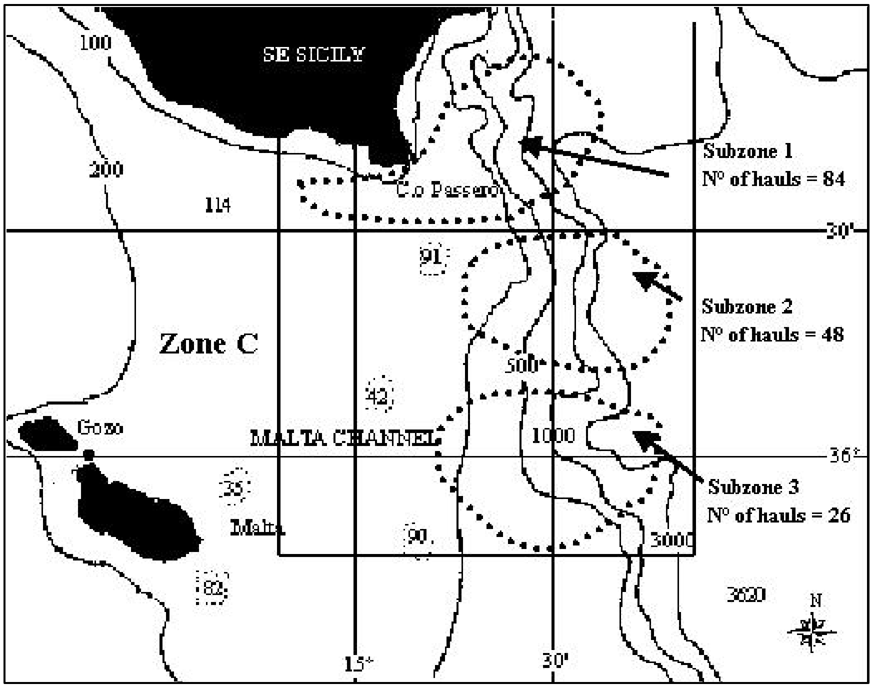


Fig. 2. Zone C and sampling details of subzones 1, 2 and 3

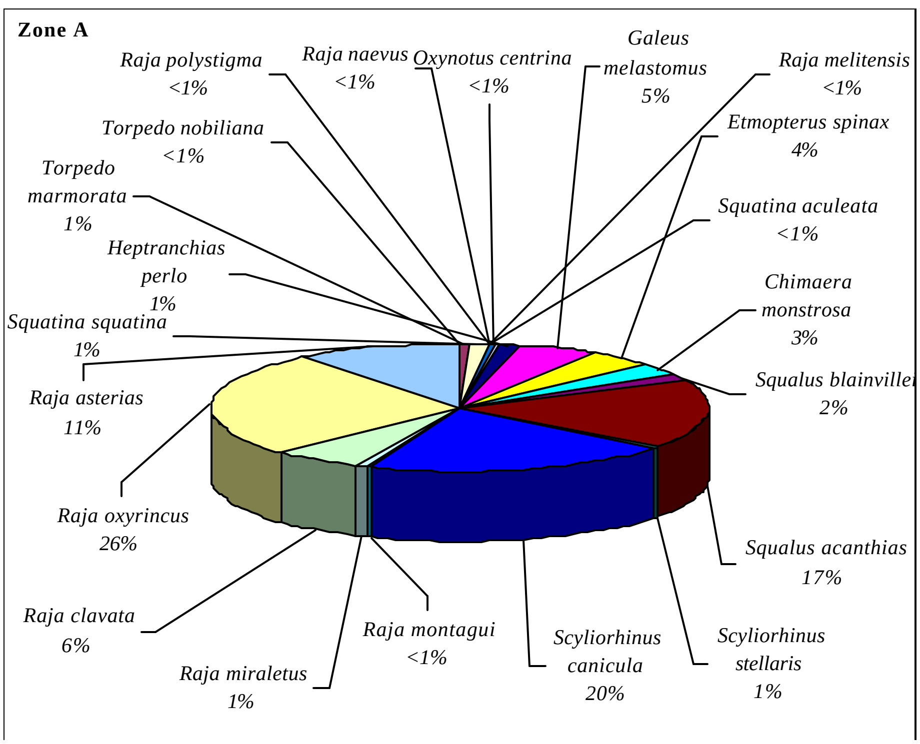


Fig. 3. Relative biomass percentages of elasmobranch species caught in zone A

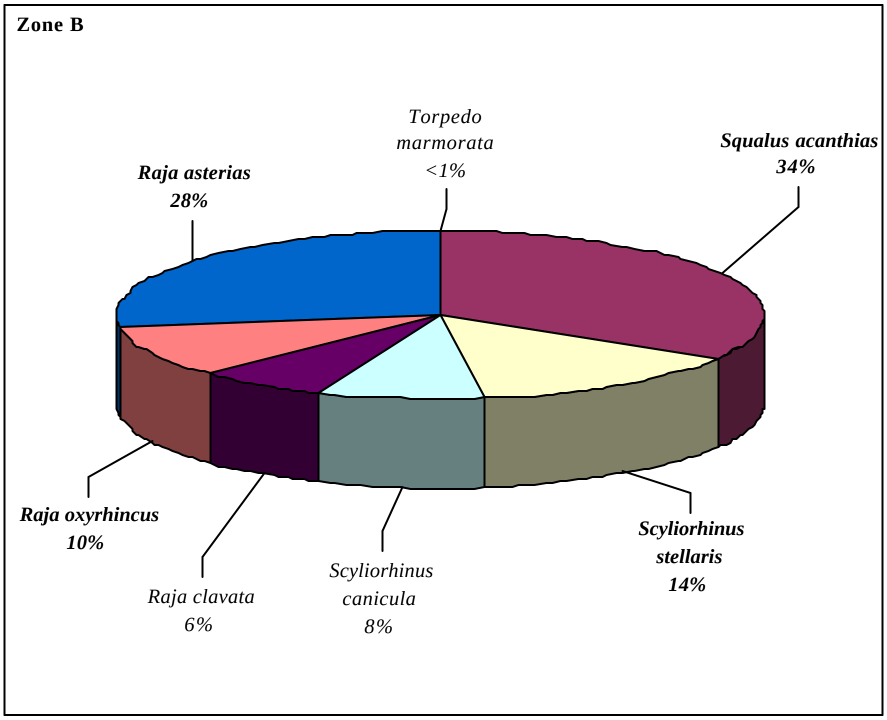


Fig. 4. Relative biomass percentages of elasmobranch species caught in zone B

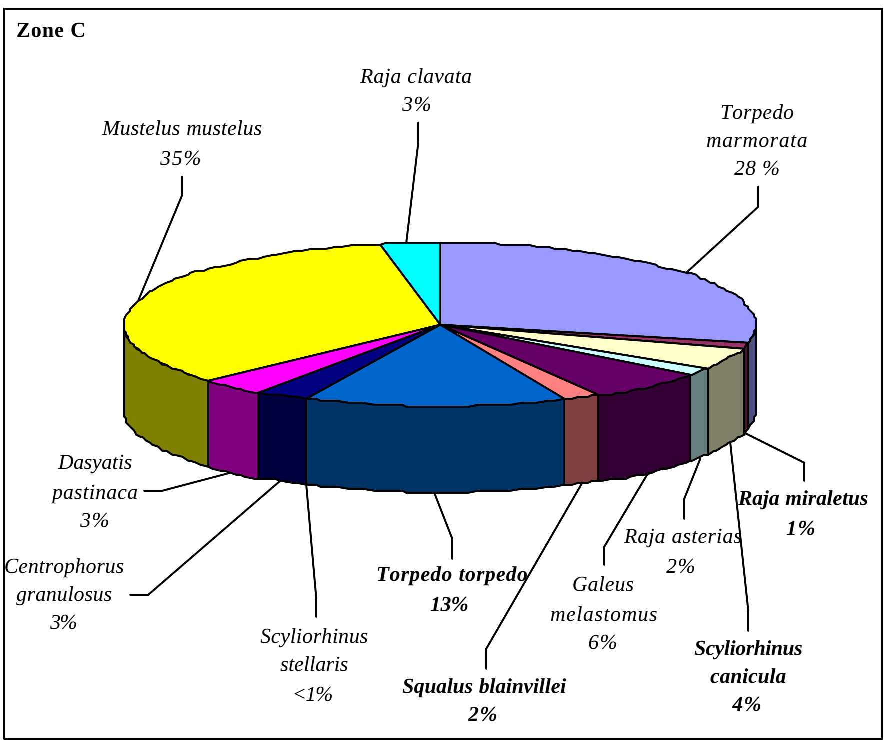


Fig. 5. Relative biomass percentages of elasmobranch species caught in zone C

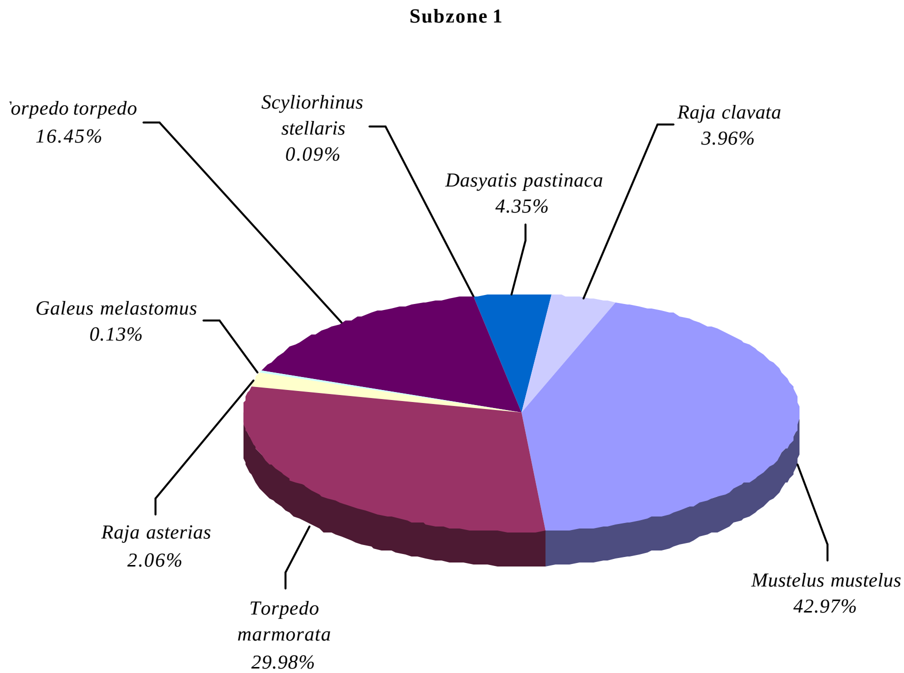


Fig. 6. Relative biomass percentages of elasmobranch species caught in subzone 1 of zone C

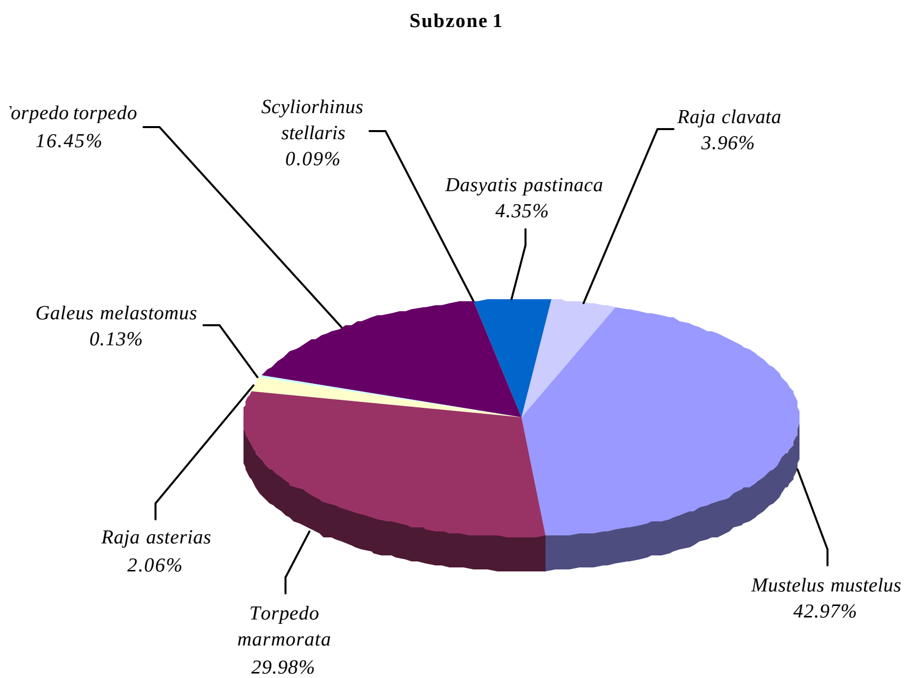


Fig. 7. Relative biomass percentages of elasmobranch species caught in subzone 2 of zone C

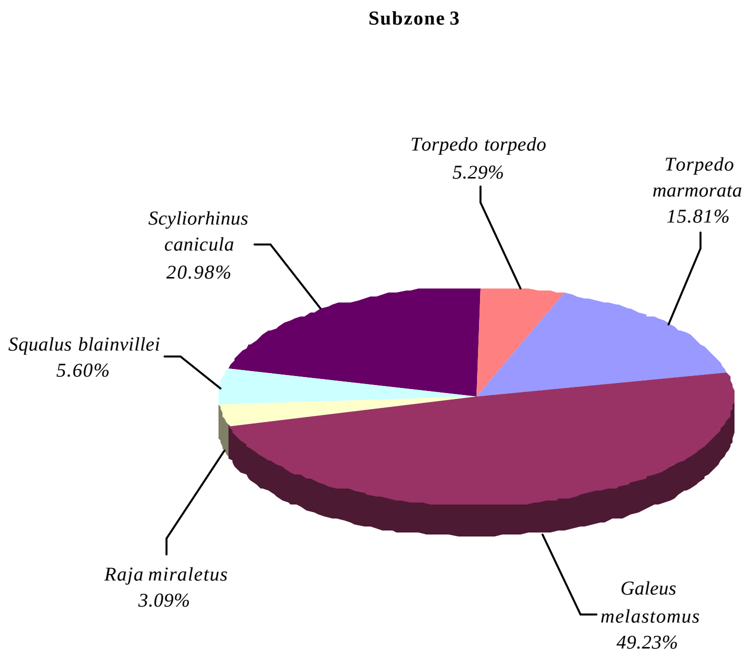


Fig. 8. Relative biomass percentages of elasmobranch species caught in subzone 3 of zone C

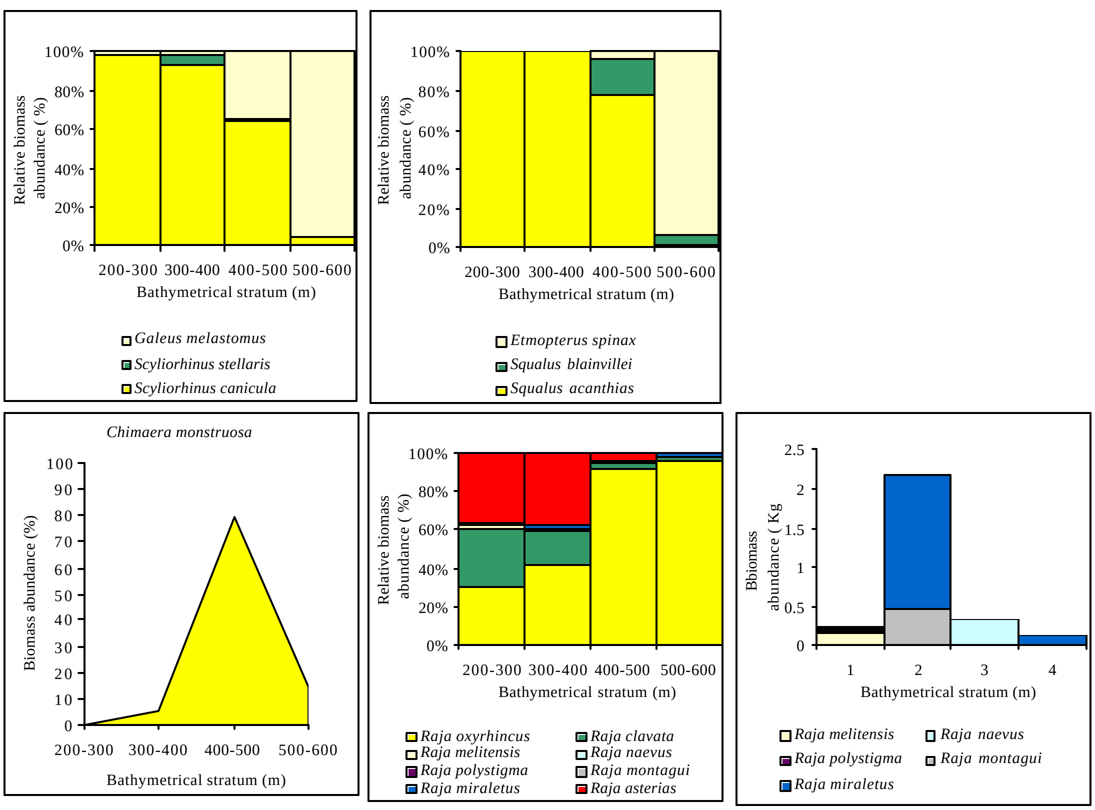


Fig. 9. Relative biomass percentages of elasmobranch species caught in zone A per bathymetrical stratum. a) Scyliorhinidae; b) Squalidae; c) Rajidae; d) biomass percentage per bathymetrical stratum of *Chimaera monstruosa* in zone A; e) biomass abundance (Kg) of other Rajidae per bathymetrical stratum of zone A.

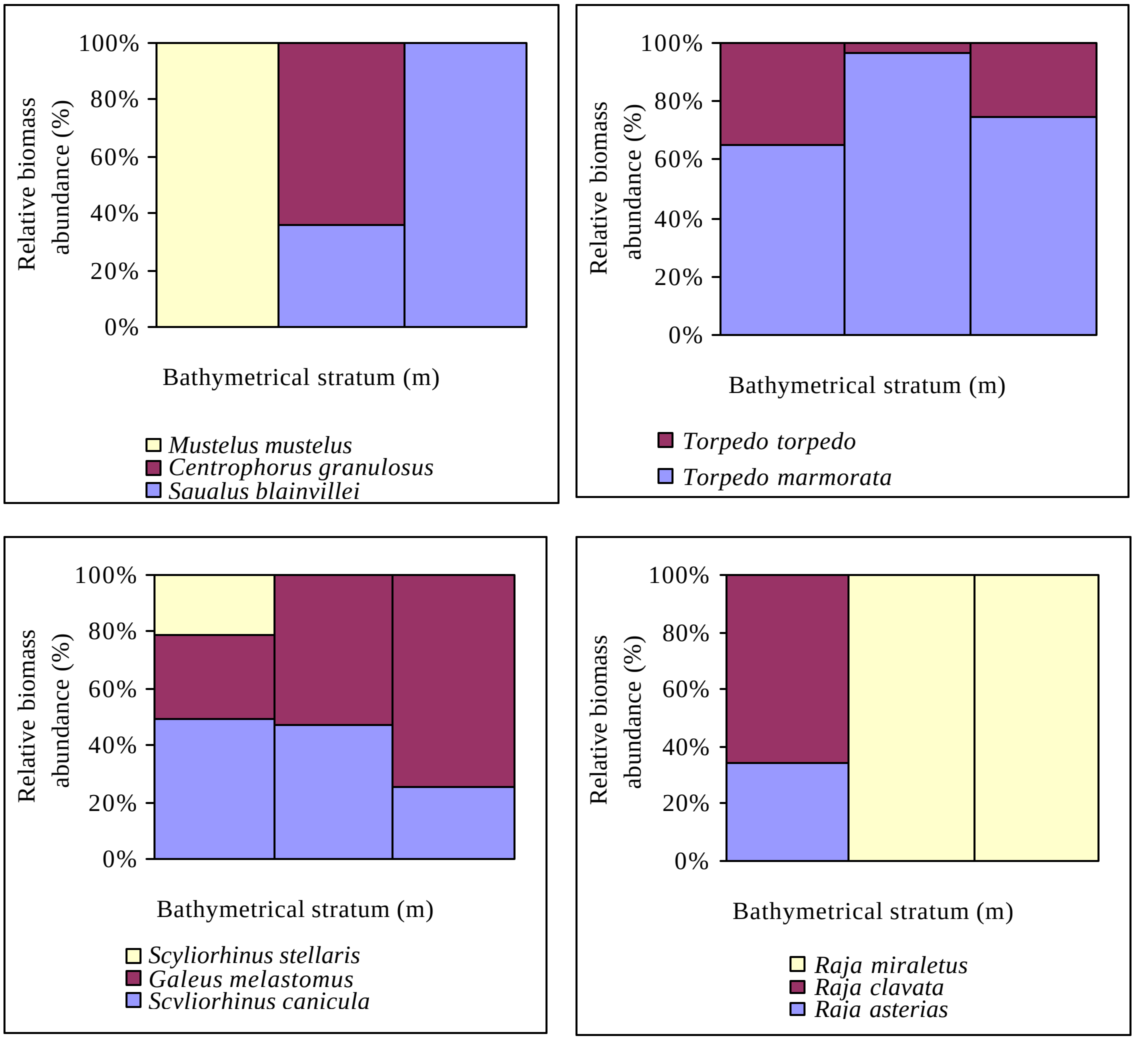


Fig. 10. Relative biomass percentages of elasmobranch species caught in zone C per bathymetrical stratum. a) Squalidae and Triakidae; b) Torpedinidae; c) Rajidae; d) Scyliorhinidae

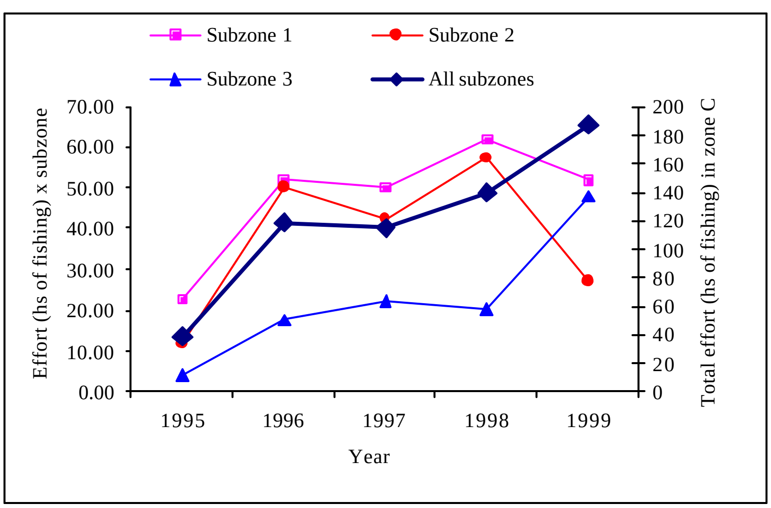


Fig. 11. On the left axis: effort expressed as hours of fishing per year in the three subzones of zone C; on the right axis: total effort in zone C expressed as hours of fishing per year.

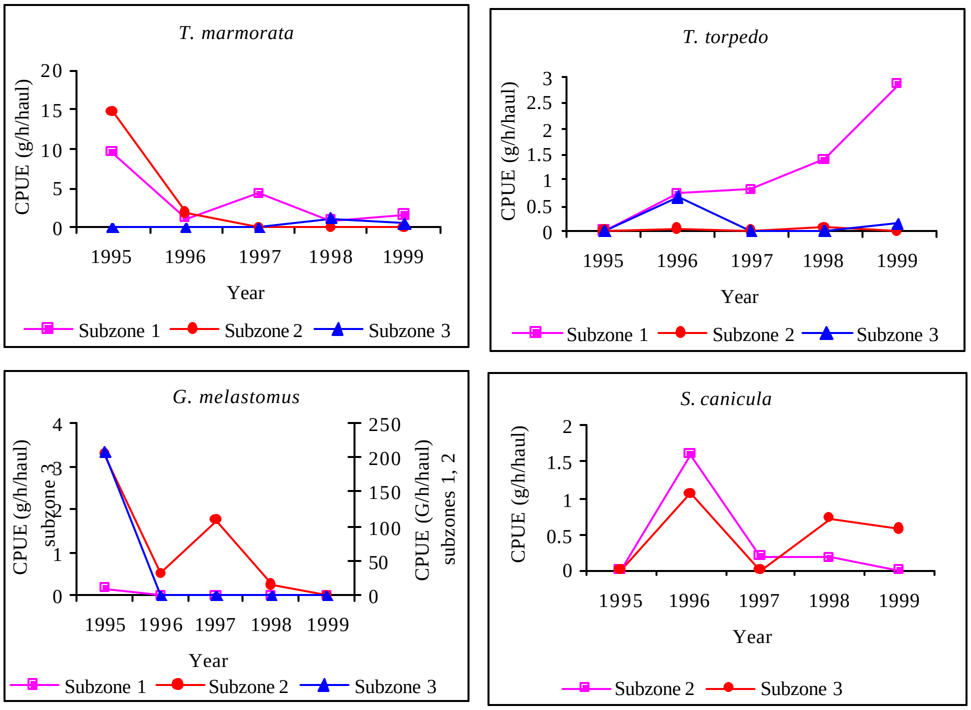


Fig. 12. Variation of CPUE expressed as grams of biomass per hour of fishing per haul for elasmobranch species caught in the three subzones of zone C in time series 1995-1999. a) *T. marmorata*; b) *T. torpedo*; c) *S. canicula*; d) *G. melastomus*; e) *R. miraletus*; f) *R. asterias*; g) *M. mustelus*; h) *R. clavata*

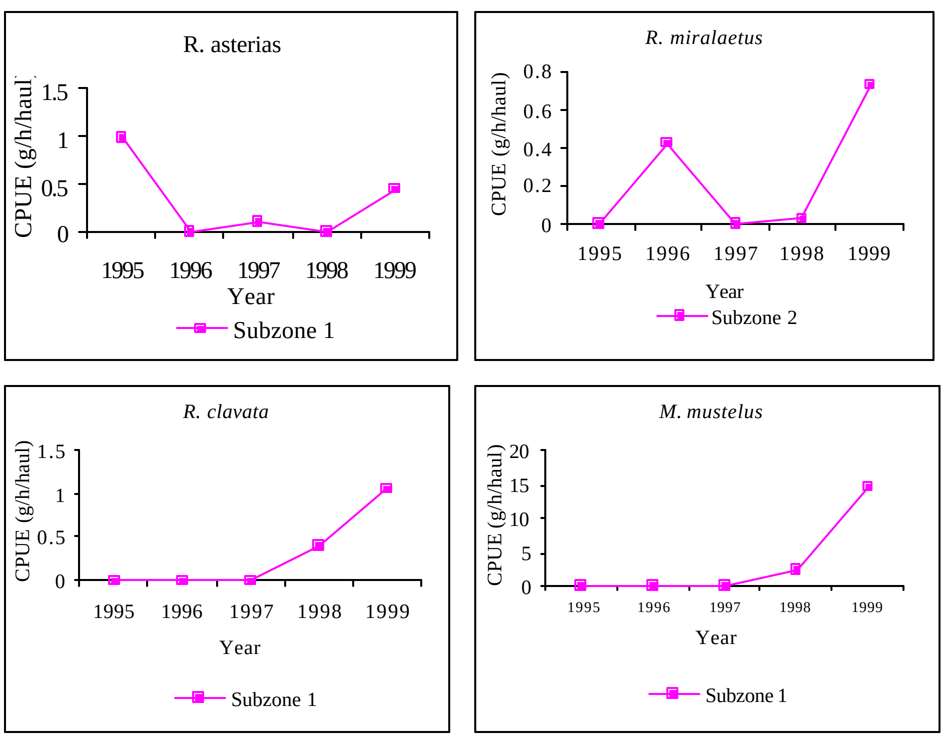


Fig. 13. Relative biomass percentages of discard and commercial fractions of elasmobranch species caught in zones A and B.

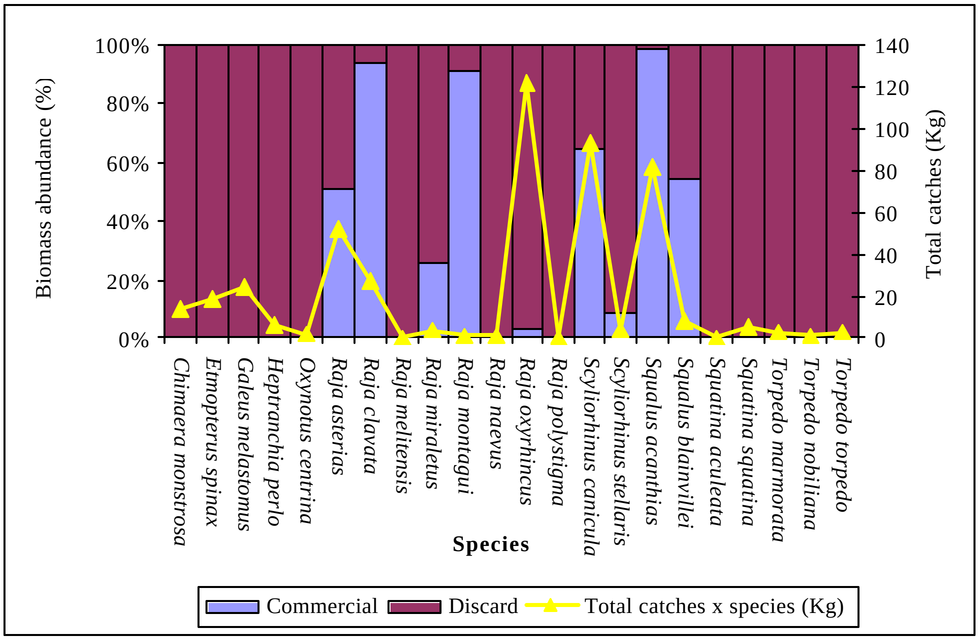


Fig. 14. Relative biomass percentages of discard and commercial fractions of elasmobranch species caught in zones C.

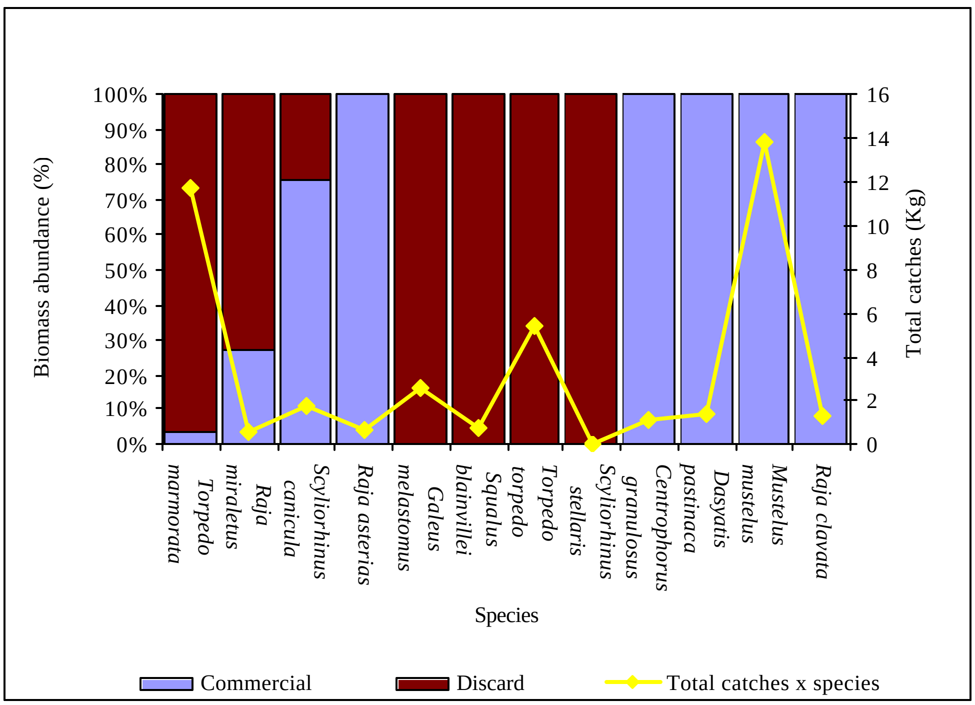


Fig. 15. Relative biomass percentages of discard and commercial fractions of elasmobranch species caught in zones C.