

The distribution and relative abundance of elasmobranch species along North-Western African shelf and slope (from Gibraltar to 16°N) as compared to retrospective data (70s-80s) and environment.

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ABSTRACT

The present paper describes the elasmobranch species communities of the Central East Atlantic lower shelf and upper slope zone. The data collected in bottom trawl survey in 2005 May-June between 16°05' N and 30°30' N were compared to retrospective data of 1970s-80s (141 cruise in total). The analysis carried out suggest no changes of occurrence and abundance or some increase in most species, but *Etmopterus pusillus*, which is significantly decreased, most probable due to environmental changes. The analysis of distribution patterns revealed gap in distribution of many species between 19 and 20°N, at the frontal zone between the main water masses of the Central East Atlantic: Northern Atlantic Central Water Mass and Southern Atlantic Central Water Mass and some other gaps, permanent and temporary. Such gaps are supposed to be boundaries between stock units of intraspecific level. The brief descriptions of occurrence, distribution and sizes of 71 species of sharks and rays are given.

Keywords: sharks, skates, Western Africa, abundance, occurrence, stock units, environmental changes.

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INTRODUCTION

Elasmobranch species attract last years more attention from international bodies and commissions as IUCN, ICES, ICCAT, WWF, etc., due to recognition of their importance for marine ecosystems from one side and stocks depletion from other side. The same time the regional review of sharks and rays, besides brief descriptions in field guides or general information in FAO Species Catalogs (Compagno, 1984, 1984A, 2002) are quite rare. The present paper is intended to compare the new data on sharks and rays of North Western Africa with the retrospective data from literature sources (Aloncle, 1970; Collignon and Aloncle, 1972; Litvinov, 1993) and to present the brief description of the species occurrence, abundance, distribution patterns and interaction with environmental changes.

MATERIAL AND METHODS

The data were collected in 2005 May-June in bottom trawl survey of STM "Atlantida" in three Parts of the Western African waters: Part I: from Cape Gir to Cape Hubi; Part II: from Cape Hubi to Cape Blanc and from Cape Blanc to Senegal River (Fig.1). Depending of the bottom relief, trawl hauls lasted about 30 min., SD 6.1 at the vessel speed of 3.0-3.6 knots. The trawl vertical opening was 6-7 m, horizontal 11.5 m. The trawl hauls were carried out at every 30' latitude at the depths of 50-99 m (Table 1).

Table 1. The distribution trawl hauls by depths.

Depths	number of trawl hauls
50-199	1
200-299	14
300-399	10
400-499	13
500-599	8
600-699	15
700-799	11
800-899	19
900-999	1
Total	93

The two parameters were used for species description: Index of the relative density (IRD) and Relative Frequency Occurrence (RFO). The methods of indices calculation and scale of the occurrence order are given in Litvinov (1993) and Patokina and Litvinov (2004).

The distribution patterns were determined when trawl hauls number and species occurrence allowed to reveal gaps in distribution, which are supposed to be boundaries of the stock units (Litvinov, 1993; 2003; Litvinov, Kudersky, 2004). Delimitation of such units was possible for the common species only, when occurrence was of dominant or subdominant level (Litvinov, 1993). The species caught, depths and TL are given in Table 2.

Table 2. The species caught in 2005 May-June along Western African coast

Species	Depths	TL
<i>Chlamidoselachus anguineus</i>	522-893	59-66
<i>Heptranchias perlo.</i>	450-610	82-102
<i>Deania calcea</i>	600-910	30-113
<i>Deania profundorum.</i>	566-893	23-82
<i>Centrophorus granulosus</i>	450-915	64-94
<i>Centrophorus squamosus.</i>	381-743	86-117
<i>Centrophorus lusitanicus.</i>	425-893	107-119
<i>Scyliorhinus stellaris</i>	264-345	29-48
<i>Apristurus spp</i>	340-836	31-64
<i>Galleus spp.</i>	280-660	9-51
<i>Centroscillium fabricii</i>	816	58
<i>Squaliolus laticaudus</i>	357-485	19-23
<i>Dalatias licha</i>	600-830	40-155
<i>Centroscymnus crepidater</i>	680-850	28-52
<i>Scymnodon ringens</i>	566-890	20-105
<i>Scymnodon obscurus</i>	300-899	30-150
<i>Etmopterus spinax</i>	386-816	11-36
<i>Etmopterus pusillus</i>	830	43
<i>Raja sp</i>	625	50
<i>Raja montagui.</i>	425-522	40-54

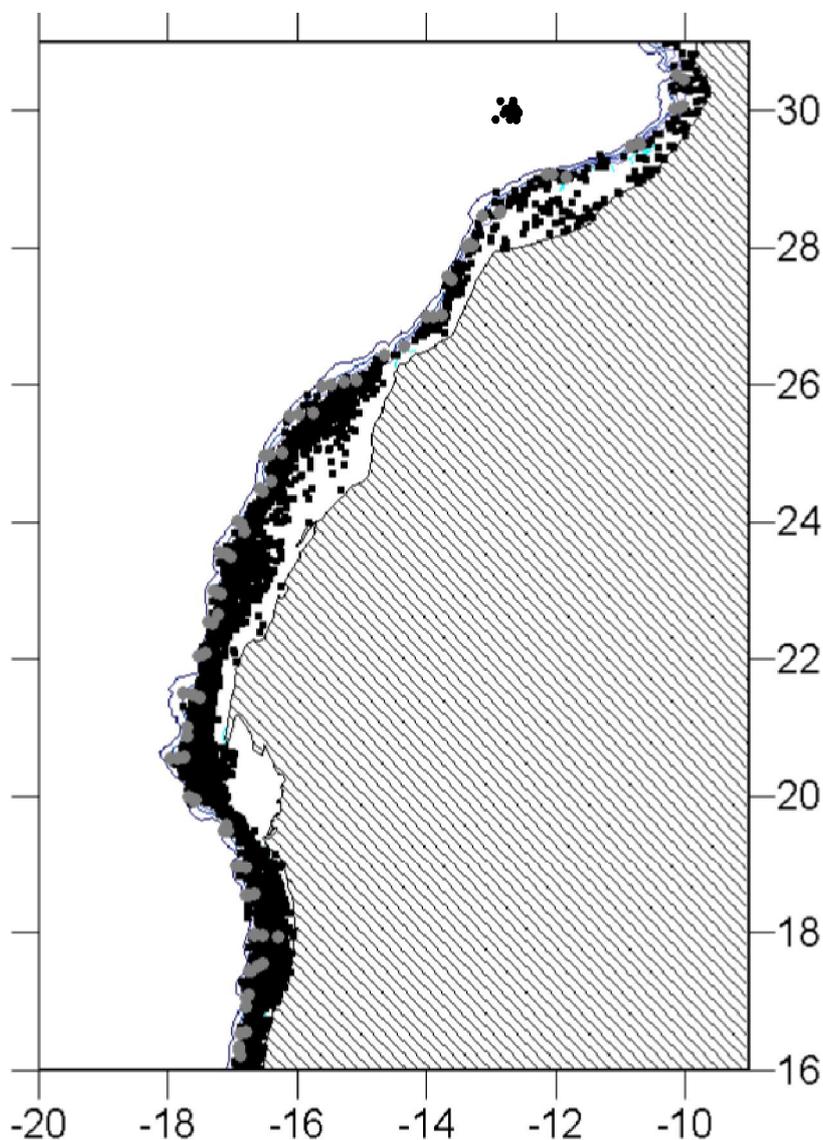


Fig.1. Trawl station positions. Grey circles: 2005 data; black circles: retrospective data (141 cruises in total).

The data collected in 2005 were compared to retrospective data (RD) from AtlantNIRO database, collected in 70s-80s. The IRD and RFO values were calculated from the four scientific surveys, the most representative ones: R/V “Belogorsk”, Parts I and II, 1972 (315 trawl hauls); R/V “Vyandra” (187 trawl hauls), Part III, 1976/77; R/V “Strelnya” (206 trawl hauls), Part III, 1987; R/V “Evrika” (83 trawl hauls), Part II, 1984. Trawl hauls were carried out by standard depths of 10, 25, 50, 75, 100, 150, 200, 300, 400, 500, 600, 700, 800 and 900 m. The data on distribution and length were taken from the total database, of 141 cruises.

RESULTS

1. SPECIES FOUND IN 2005

Family CHLAMIDOSELACHIDAE

Chlamidoselachus anguineus. This is one of the rarest species in the area. The sporadic captures in the past were specially reported in literature (Domanevskii, 1975). There were captured two specimens in 2005: at 522 m depth near 22°N, male 59 cm TL, 0.441 kg; and at 893 m depth near 18°N, male, 66 cm TL, 0.534 kg.

Family HEXANCHIDAE

Heptranchias perlo. This is a quite rare shark, in the past just single captures were reported in Moroccan waters at 490 m and in Sierra Leone at 100 m depth (Litvinov, 1993). However, it was quite common on the submarine mounts southward Azores (Litvinov, 1984). There were caught five specimens in 2005: at 450 and 610 m near 26°N and at 410 m near 22°N. TL ranged from 82 to 100 cm; all the specimens caught were males.

Family CENTROPHORIDAE

Deania calcea. It was found in 2005 at 600-910 m depth as common species of dominant or subdominant level (it was presented in 3 of 15 trawl hauls at 600 m; 2/11 at 700 m; 11/19 at 800 m and in 1/1 at 900 m depth), corresponding in general the data given in Litvinov (1993) for Moroccan waters. IRD ranged from 1 to 16, mean value (MV) 6,8; SD 4.9. Inside Part II TL ranged from 30 to 113 cm, modal value 85 cm (Fig. 2), sex ratio 1:1.2. Inside Part III TL ranged from 43 to 63 cm, sex ratio 1:2.5.

The species is known in Eastern Pacific from Iceland to 10°N (Compagno, 1984). The summarized map of distribution clearly demonstrates gaps between 19 and 20°N, and 24 and 25°30'N according to the new and retrospective data (Fig.3). The trawl hauls were rather abundant there (see Fig.1), so this gap cannot be considered as artifact caused by lack of trawl hauls carried out. So, one may suggest the isolated stock units there, as for some other elasmobranch species (Litvinov, 2003). According to retrospective data there was wide gap between 23 and 28°N in the past; it was not stable, however. According to retrospective data (RD) IRD ranged from 1 to 372, MV from 12 (SD 7.9) to 156.3 (SD 100.5).

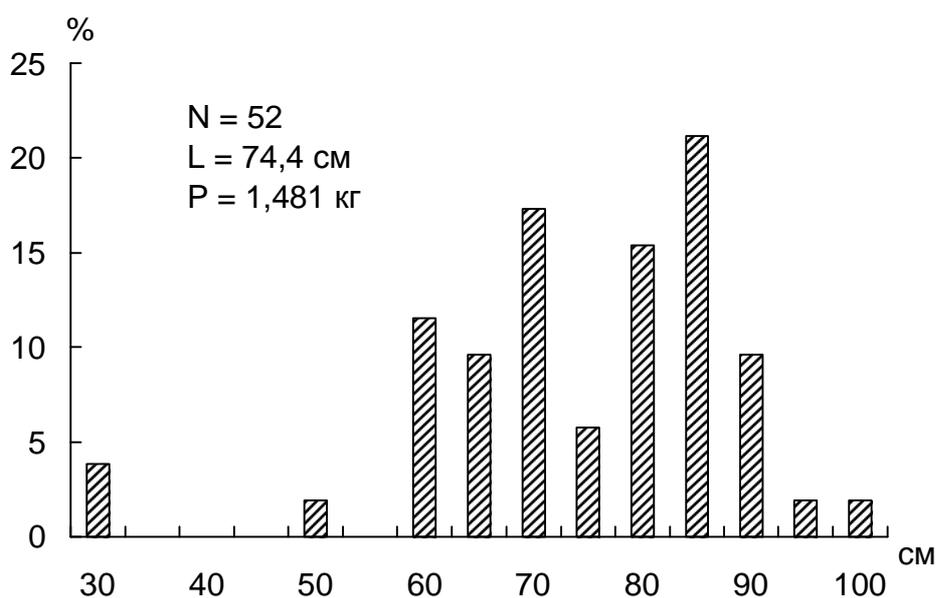


Fig.2. Length frequency distribution of *Deania calcea* in Part II.

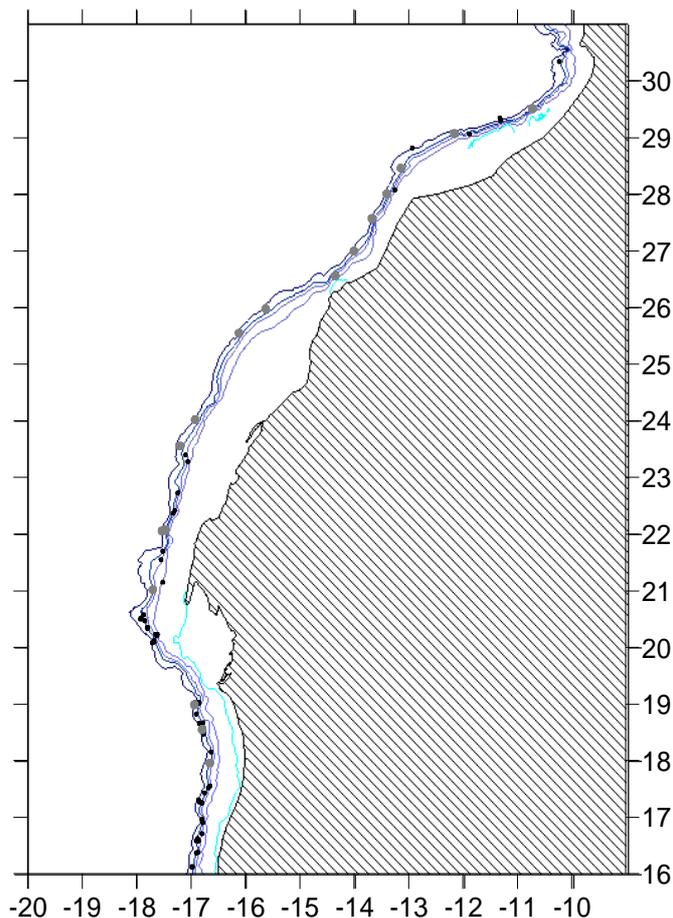


Fig. 3. Distribution of *D. calcea*. Here and after: grey circles – 2005; black circles: retrospective data (1970s-80s).

Deania profundorum. In 2005 it was dominant and subdominant at 600-899 m (4/15 at 600; 3/11 at 700; 9/19 at 800). RFO values were higher comparing ones reported in Litvinov (1993). In Part II TL ranged from 23 to 83, modal value 60 (Fig. 4), sex ratio 1:1.4. In Part III TL ranged from 56 to 75 cm, sex ratio 1:0.42. IRD ranged from 1 to 38, MV 12.6, SD 11.3. Froese and Pauly (2006) reported it in Western Sahara waters and further to South; according to 2005 and Litvinov (1993) data it occurred at least northward to 31°N (Fig.5). There is a gap in distribution at 19-20°N, like in *D. calcea*, and another one, much wider, from 24 to 27°N. According to RD, IRD ranged from 1 to 84, aggregation were rather common. The two species, *D. calcea* and *D. profundorum*, are often caught by the same trawl haul.

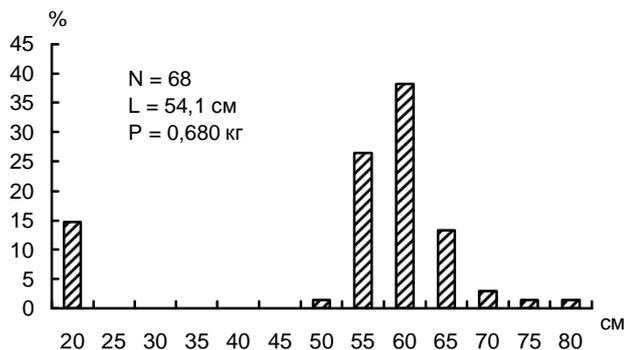


Fig.4. Length frequency distribution of *Deania profundorum* in Part II.

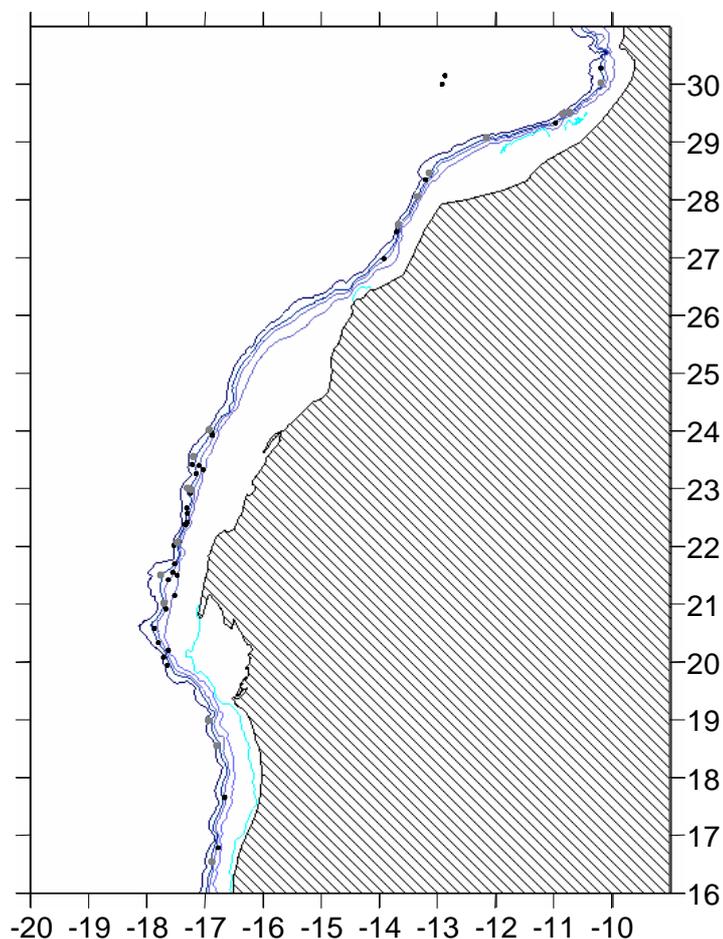


Fig. 5. Distribution of *Deania profundorum*. Legend corresponds to Fig. 3.

Family CENTROPHORIDAE

Centrophorus granulatus. In 2005 it occurred at 450-915 m depth. It is dominant or subdominant species at 400-800 m (3/13 at 400; 2/8 at 500; 6/15 at 600; 2/11 at 700) and deeper it is more rare (1/19); the data correspond to Litvinov (1993) in general. IRD ranged from 1 to 7, MV 2.3, SD 1.8. In Part II TL ranged from 64 to 94 cm; in Part III from 64 to 90 cm, sex ratio 11,5:1. The species is known in Eastern Atlantic from France to South Africa (Froese, Pauly, 2006). The distribution pattern is different from that of *D. calcea* and *D. profundorum*: there are no gaps at 19-20°N and 24-27°N. There is another gap between 28 and 29°N (Fig. 6). However, in 2005 the species was absent from 24°30'N to 27°30'N. Thus, *C. granulatus* have had in 2005 the same gap in distribution as *D. profundorum* has permanently and *D. calcea* had 1970s-80s. So, the phenomenon of the antifase does exist in the presence of *C. granulatus* and *D. calcea* between 25 and 27°N.

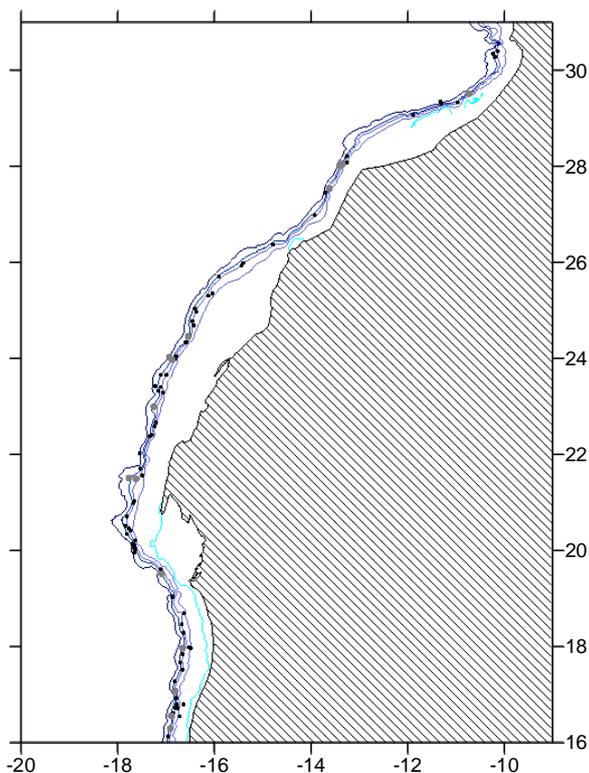


Fig. 6. Distribution of *C.granulosus*. Legend corresponds to Fig. 3.

Centrophorus squamosus. In 2005 it was found at 600-899 m (3/15 at 600; 3/11 at 700; 2/19 at 800 m depth) and at 300 m (1/10). IRD ranged from 1 to 12, MV 3.3, SD 3.1. In Part II TL ranged from 86 to 117 cmm, sex ratio 1.5:1. In Part III TL ranged from 45 to 69 cm, females prevailed. According to retrospective and Litvinov's (1993) data, just single specimens were caught during all the period, so in 2005 there was observed the highest abundance since 1972. The species was more abundant from 16°N to 22°N than northward. However it reached 39°N (Fig.7).

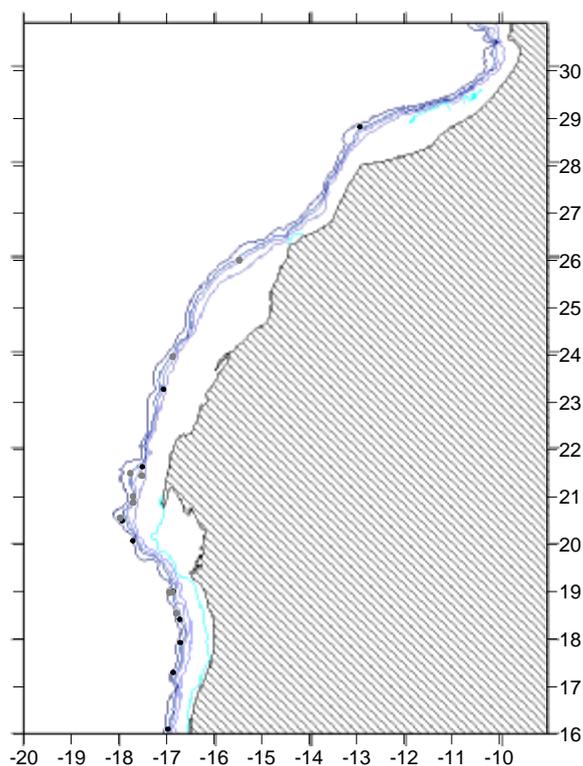


Fig. 7. Distribution of *Centrophorus squamosus*. Legend corresponds to Fig. 3.

Centrophorus lusitanicus. Less common species comparing *C. granulatus* and *C. squamosus*. It was found at 400-899 m (1/13 at 400; 1/11 at 700 2/19 at 800 m depth), corresponding to Litvinov's (1993) and our RD in general. In Part II TL ranged from 111 to 113 cm (weight 6.3-8.2 kg); in Part III TL ranged from 107 to 119 cm (weight 7-11.6 kg), sex ratio 5:0. Distribution pattern similar to *C. squamosus* (Fig. 8); the species was more frequent southward 22°N, reaching 29°N, however.

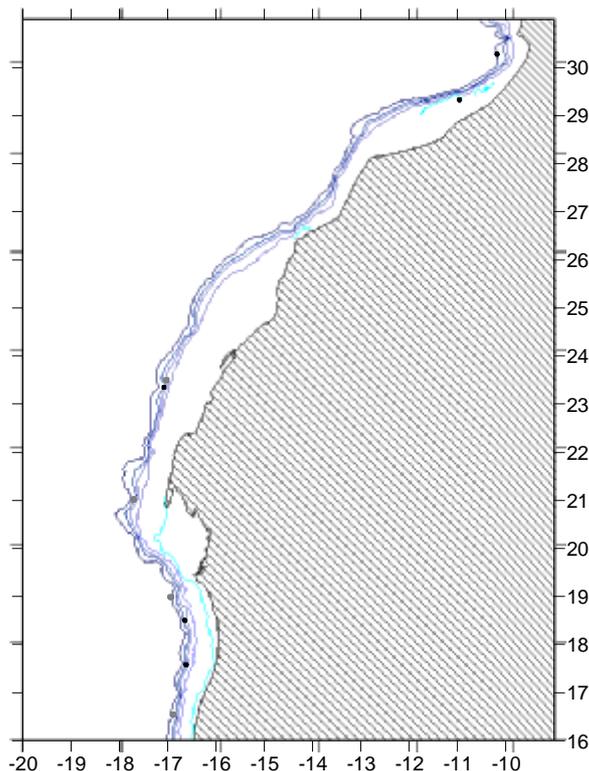


Fig. 8. Distribution of *Centrophorus lusitanicus*. Legend corresponds to Fig. 3.

Family DALATIIDAE

Centroscyllium fabricii. Compagno (1984) describes it as an abundant schooling species. However, the one female only was caught in 2005, at 816 m depth; TL 59 cm, weight 0.782 kg. Litvinov (1993) did not mention this species at all; it is absent from retrospective data. Thus, it is quite rare species in the area investigated, at least at the depths less 900 m.

Squaliolus laticaudus. There were caught 3 females of 19-23 cm TL, at the depths of 300-499 m at 27-28°N. Litvinov (1993) did not mention this species; it is absent in retrospective data, probably due to its pelagic habits.

Dalatias licha. There were caught two females at 600 and 800 m depth, near 22 and 26°N; of 40 and 155 cm TL. Litvinov (1993) mentioned this species as rear (subresident) at 400 and 600-900; according to retrospective data it occurred at the depths of 400-600; IRD ranged from 1 to 6, MV 1.8, SD 1.8. According to Compagno (1984), it occurs from North Sea to Senegal; according to 2005 and retrospective data, all the specimens were caught southward 26°30'N, the type of distribution is very similar to *G. polli* (Fig.9).

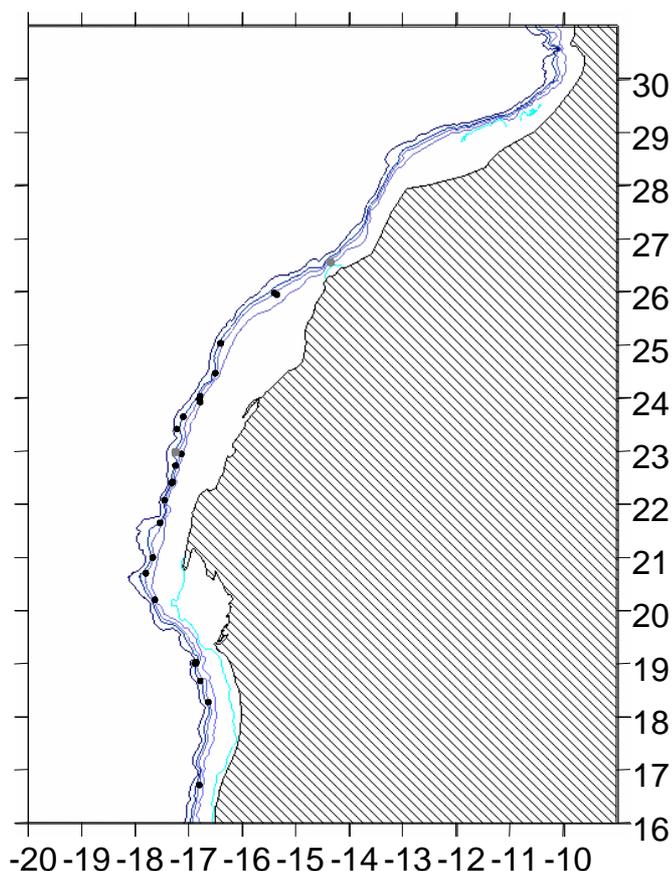


Fig. 9. Distribution of *D. licha*. Legend as for Fig. 3.

Centroscymnus crepidater. It was caught at 600 (1/15), 700 (1/11) and 800-899 (4/19) m depth, near 21-24°N. TL ranged from 28 to 52 cm. Litvinov (1993) noted its presence at 800-900 m and absence northward 34°N; according to retrospective data it occurred from 500 to 800 m, IRD was 1-2, corresponding to “singular appearance” in Compagno, 1984. The distribution pattern is very similar to *D. profundorum*, there are gaps at 19-20°N and 24-28°N.

Scymnodon obscurus. It was relatively rare at 300 (1/10), 600 (1/15) and more frequent at 800-899 m (4/19). Litvinov noted it at 600-900 m, mostly northward 34°N. The distribution pattern is very similar to *D. profundorum*, there are gaps at 19-20°N and 24-28°N. TL ranged from 30 to 105 cm.

Scymnodon ringens. It was relatively rare at 500 (1/8), 600 (1/15), 700 (1/11) and rather frequent at 800-899 m (7/19); IRD ranged from 1 to 12, MV 2.4, SD 3.4. The female of 105 cm TL was caught at 23°30'N and 17°00'W; it aborted 11 embryos of 20 cm TL. Litvinov (1993) noted it at 600-900 m, evenly distributed along Moroccan slope. The distribution pattern is very similar to *C. crepidater* and *D. profundorum*: there are gaps at 19-20°N and 24-26°30'N.

Etmopterus spinax. It was caught at 300 (1/10), 400 (4/13), 500 (2/8), and 600 m (2/15). IRD ranged from 1 to 97; MV 16.0, SD 29.3. TL ranged from 11 to 34 cm, the shortest specimens 11-14 cm were caught at 420 m depth, near 23°50'N. The majority of specimens were brown (grey)-black (corresponded to Compagno, 1984); one specimen caught at 680 m near 24°N was bright blue. Litvinov (1993) noted this species at 400-900 m, mostly northward 34°N, in contrary to some other elasmobranch species (Litvinov, 2003). According to retrospective data, IRD ranged from 1 to 90; MV 21.7, SD 13.2. As in many other species, there is a gap in distribution from 19 to 20°30'N. Another gap is variable, as in *D. calcea*: according to

retrospective data it was absent northward 26°N; in 2005 it was found from 27°30'N to 29°30'N, but was absent from 24 to 27°30'N (Fig. 10). Comparison of 2005 and retrospective data reveal the significant shift northward. The species was found at Conception Bank.

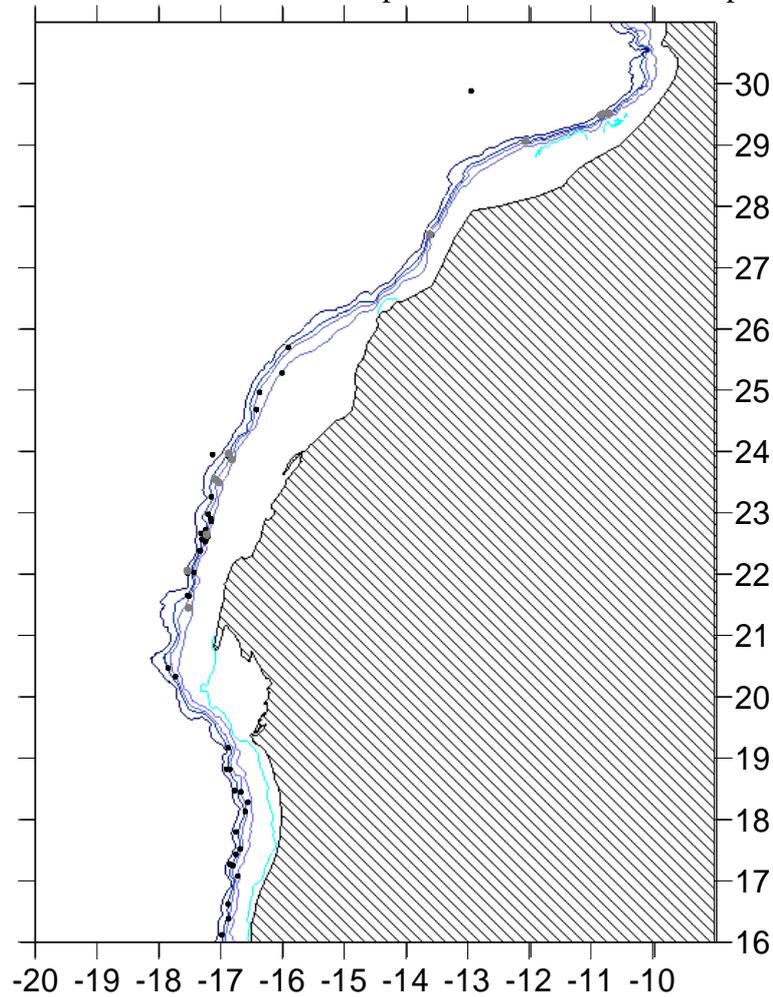


Fig. 10. Distribution of *E. spinax*. Legend as for Fig. 3.

Etmopterus pusillus. One specimen was caught at 830 m, male of 43 cm TL. Litvinov (1993) noted it at 400-900 m, mostly northward 34°N, the aggregations were found of 16-25 IRD values. According to retrospective data, it was absent southward 20°N (in accordance with Compagno, 1984) and less frequent northward 27°30'N Fig. 13. IRD ranged from 1 to 264, MV 80.6, SD 53.8. It seems to be significantly less frequent and abundant in 2005, comparing Litvinov (1993) and retrospective data, probably due to environmental factors caused shift in distribution of *E. spinax* (Fig.11).

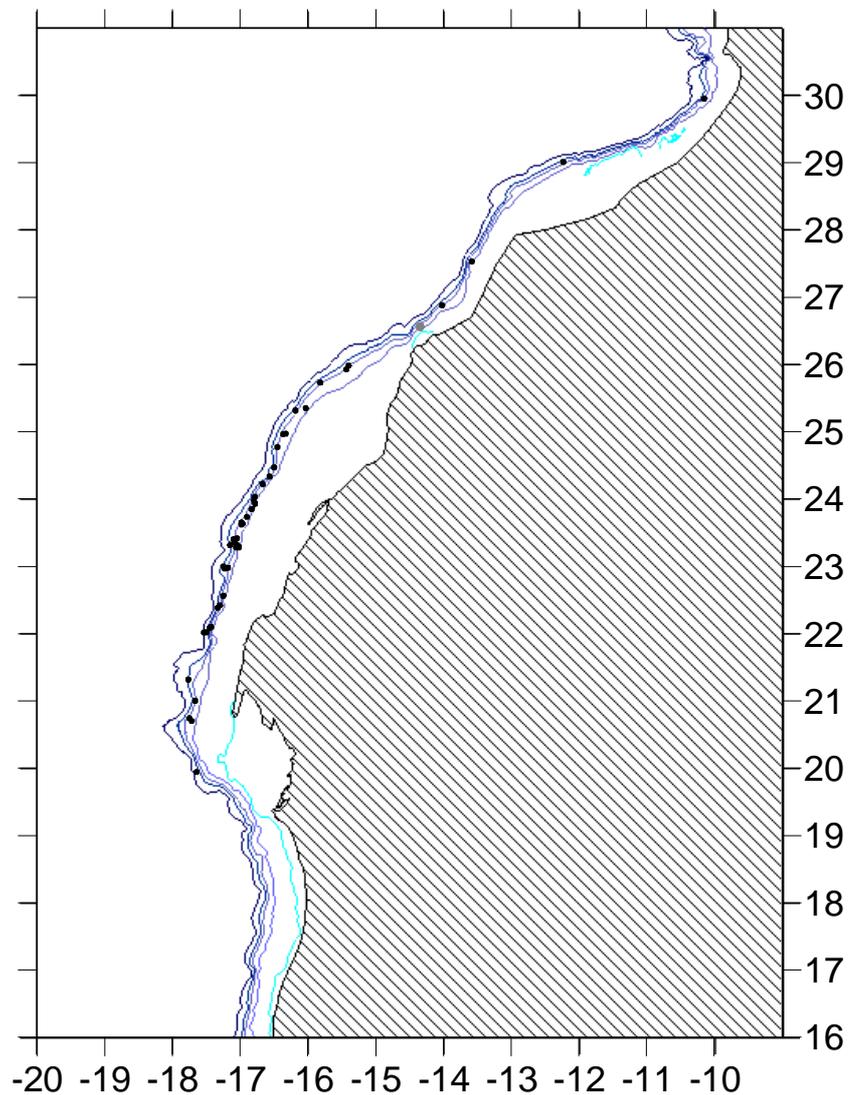


Fig. 11. Distribution of *E. pusillus*. Legend as for Fig. 3.

Family SCYLIORHINIDAE

Scyliorhinus stellaris. It was quite rare species in 2005, according to the depth range investigated: 4 specimens were caught at 264 (47-48) cm TL and 1 specimen at 345 m (29 cm TL). According to RD the species occurred at 50-380 m, IRD ranged from 1 to 10, TL 44-57 cm. According to Litvinov (1993) and our retrospective data the species was observed southward 29°N, being significantly less abundant comparing *S. canicula* (see below).

Apristurus spp. There are five species which may occur in the area: *A. atlanticus*, *A. laurussoni*, *A. maderensis*, *A. manis*, *A. nasutus* and *A. profundorum* (Compagno, 1984). Our specimens were not identified to the species level. Those were caught at 300 m (1 of 10 trawl hauls), 400 m (1/13) and 836 m (1/19), from 21°N to 29°30'N. There were caught 5 specimens in total, the deepest one was possibly *A. maderensis*, of the 64 cm TL; other ones were of the 31-39 cm TL. Litvinov (1993) mentioned one unidentified specimen at 880 m.

Galeus spp. There are three species in the area: *G. atlanticus*, *G. melastomus* and *G. polli* (Compagno, 1984; Rey et al, in press). Our specimens were not identified to the species level. Those were mostly *G. polli* and *G. melastomus* which were caught together from 200 to 699 m depth, from 28°30'N southward. The occurrence increased with depth: 1/14 at 200-299 m; 2/10 at 300 m; 5/13 at 400 m; 3/8 at 500 m and 6/15 at 600 m. IRD ranged from 1 to 7, being 2.1 SD 1.8 in average. The TL ranged from 9 to 51 cm, smaller specimens were caught at 386-660 from 20 to 23°N. Litvinov (1993) noted presence of *G. melastomus* at 300-900 m depth on the slope

with IRD of about 5; the same time the species was much more abundant on the submarine mount Conception: IRD was equal to 27, the species was caught in 3 trawl hauls of 4. The distribution was nearly even through Moroccan coast. The summarized map of distribution revealed gap from 27°30'N to 28°30'N. According to retrospective data the species may create rather dense aggregations: IRD may range from 1 to 130, MV 37.2, SD 33.4. All the data indicate presence of the species from 300 m depths; however, Litvinov (1993) observed the eggs of *G.melastomus* at the depth of about 100 m in waters of Sierra Leone; most probable the species used the warmer shelf waters to accelerate eggs' development.

According to the retrospective data, the other species, *G.polli*, occurred mostly southward 26°30'N, and once was caught at 28°30'N, it correspond the literature data (Compagno, 1984). Similar to *G. melastomus*, it may create aggregations: IRD ranged from 1 to 234, MV 86.54, SD 37.2. It is possible, that the two species might be mixed in the past, but the maps of distribution indicate, that identifications were quite correct (Fig. 12; 13).

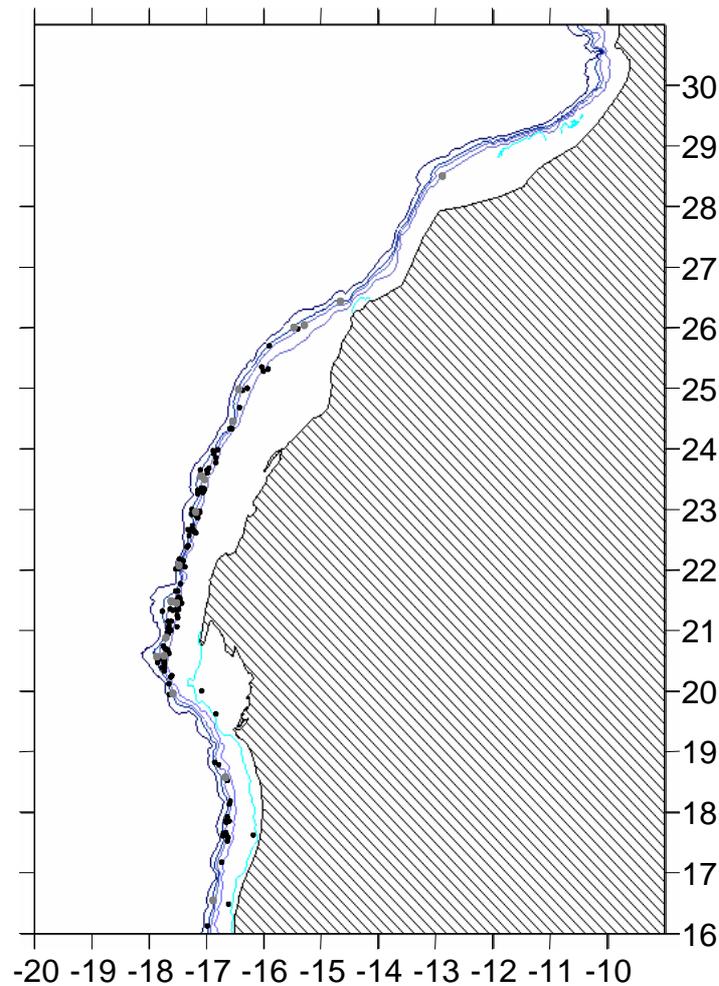


Fig.12. Distribution of *G.polli* (black circles, retrospective data) and *Galeus spp.* (grey circles, 2005 data).

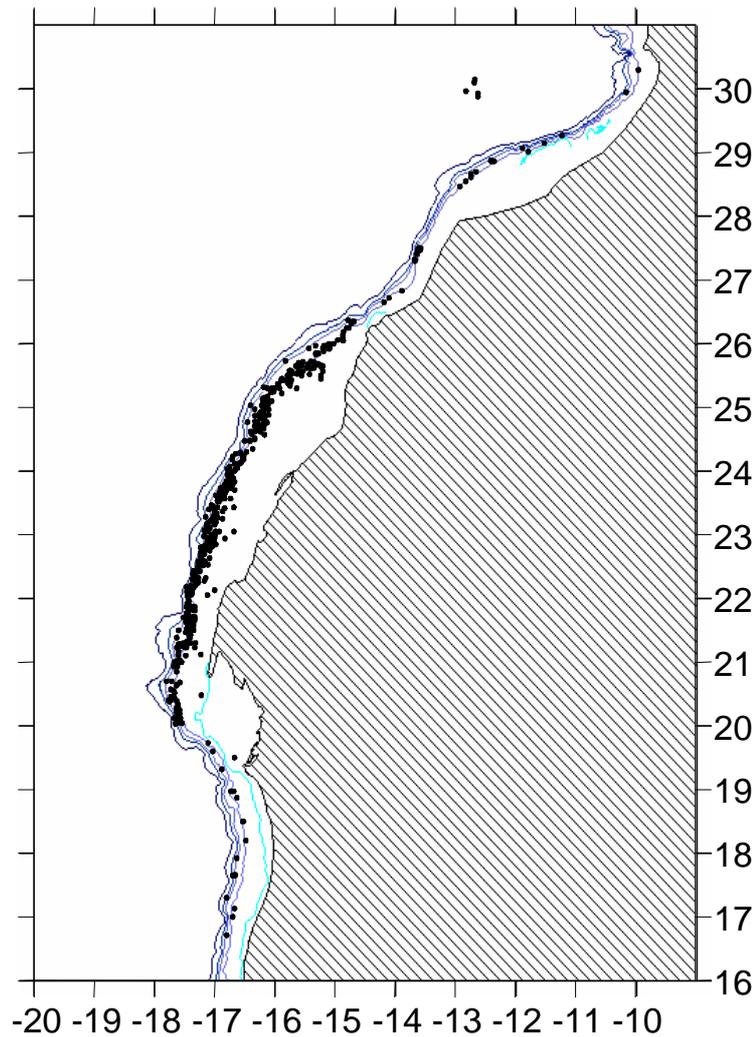


Fig.13. Distribution of *G.melastomus*, retrospective summarized data.

2. OTHER SPECIES

Centrophorus uyato. Compagno (1984) describes this species as “commonest below 200 m”. Litvinov (1993) noted it as rare, subresident species at 800-900 m depth. According to retrospective data it occurred at 200-500 m. It was not abundant (IRD ranged from 1 to 4), but rather frequent species, sporadically up to the subdominant level. Its absence in 2005 is unclear, possibly due to some environmental events caused gaps in distribution of *C.granulosus*. However, as it was assessed as quite rare species in the past, its absence may be due to random factor.

Centroscymnus coelolepis. Compagno (1984) describes it as common species below 400 m, with a depth range of 270-3675 m. Litvinov (1993) did not mention it. According to retrospective data, it was once caught at 500 m depth near 20°N, 5 specimens in total. So, it may be considered as one of the rarest species for the area and depth range investigated.

Squalus acanthias. Compagno (1984) characterizes it as “extremely abundant” for some areas, but it is not true for the area considered. Litvinov (1993) noted two commonest species of the area, *S. acanthias* and *S.blainvillei*, as quite rare, resident and subresident at 25-800 m depth.

According to retrospective data, *S. acanthias* occurred from 75 to 400 m, RFO of the resident level, IRD from 1 to 300 (once only). MV 32, SD 81.92.

It was commonest from 22 to 26°N, absent from 26 to 28°N and quite rare southward 22°N (Fig.14).

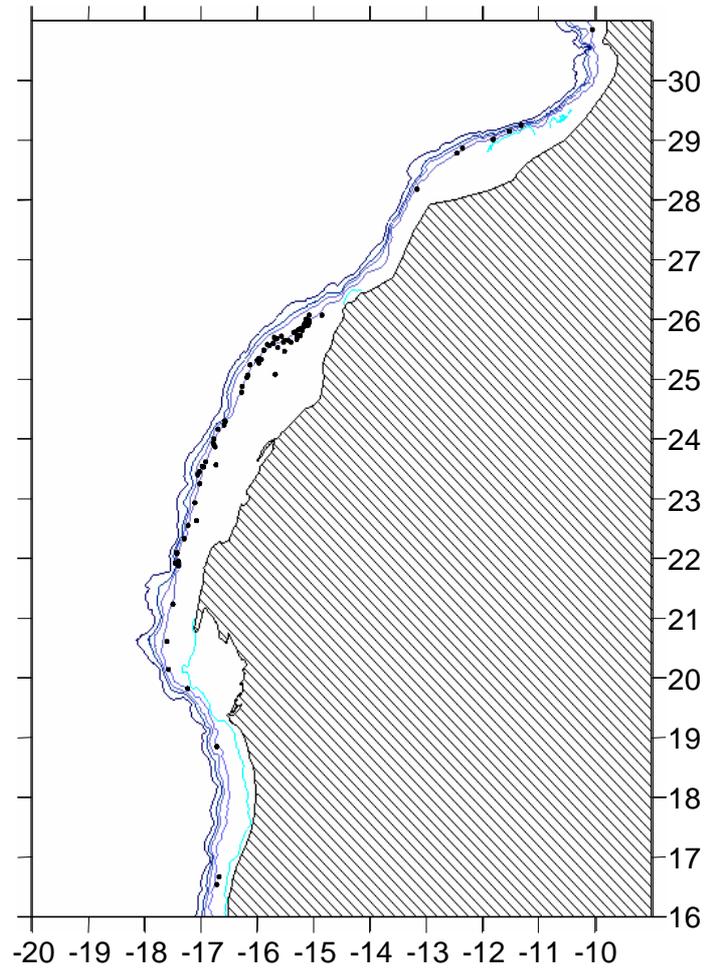


Fig. 14. Distribution of *S. acanthias* by retrospective data.

Squalus blainvillei. The distribution pattern is similar to *S. acanthias*: it was commonest from 22 to 26°N, and rare from 26 to 28°N and southward 22°N (Fig.15). It occurred at 46 m depth (once) and from 150 to 300 m, RFO of the subresident level, IRD from 1 to 11, MV 4.3, SD 4.4. Conception

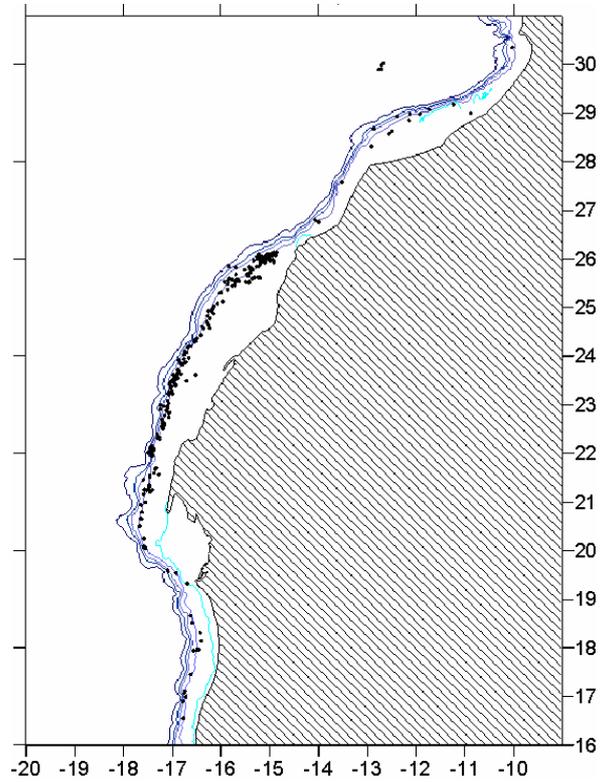


Fig. 15. Distribution of *S. blainvillei* by retrospective data.

Oxynotus centrina. It was found from 16°30' to 28°30'N along the coast, Conception Bank included, being rather common at all the depths from 57 to 600 m. TL ranged from 25 to 90 cm, being mainly 40-60 cm. Litvinov (1993) reported it as rare subresident species at 50-100 m northward 30°N.

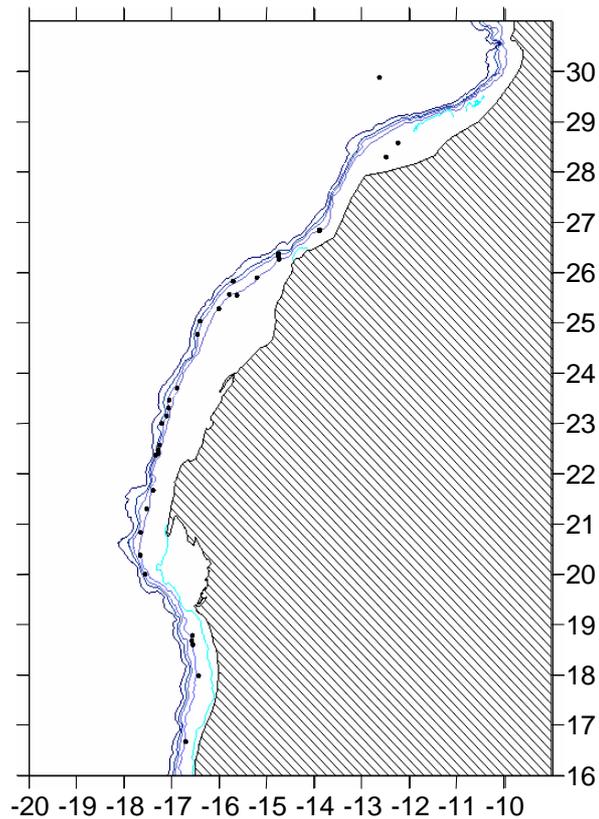


Fig. 16. Distribution of *O. centrina* by retrospective data.

Oxynotus paradoxus. It occurred along shelf break from 18 to 28°N at the depths of 125-825, mainly 470-840 m. TL was 60-62 cm. Litvinov (1993) reported one capture only at 825 m.

Squatina aculeata. Litvinov (1993) did not report it in Moroccan but in Sierra Leone waters only, at 25-300 m, southward 8°N. According to RD, it was found from 16 to 29°N at 50-415, mainly 50-160 m depth. TL ranged from 96 to 154 cm, IRD was 1-2; Litvinov reported two captures in Sierra Leone of 14 and 22 specimens at 197 and 260 m.

Squatina oculata. Litvinov (1993) reported it as subresident and resident species at 50-150 m; it was never found northward 30°N, so isolated stock unit in Western African waters may be suggested; there is an another gap in distribution at 8°N. The captures points in RD are scattered from 10 to 30°N at 28-230 m depth. TL ranged from 51 to 115 cm, IRD was 2-4; Litvinov reported one capture in Sierra Leone of 22 specimens at 160 m.

Squatina squatina. According to RD, it was found from 17 to 27, mainly to 21°N from 20 to 320, mainly to 105 m depth.

Isurus oxyrinchus. This is an epipelagic oceanic species common for the area but far less abundant comparing other pelagic sharks (Litvinov, 1989). The specimens caught by bottom trawl along the coast from 16°30'N to 28°N (Fig. 27) at the depths from 40 to 900 m, were exclusively young sharks of 74-145 cm TL. Probably, this species form in shallow coastal waters "kindergartens" like blue shark (Litvinov, 2006) which are extremely endangered from artisanal gillnet fleet (see *Sphyrna mokarran* and *S. lewini* here below).

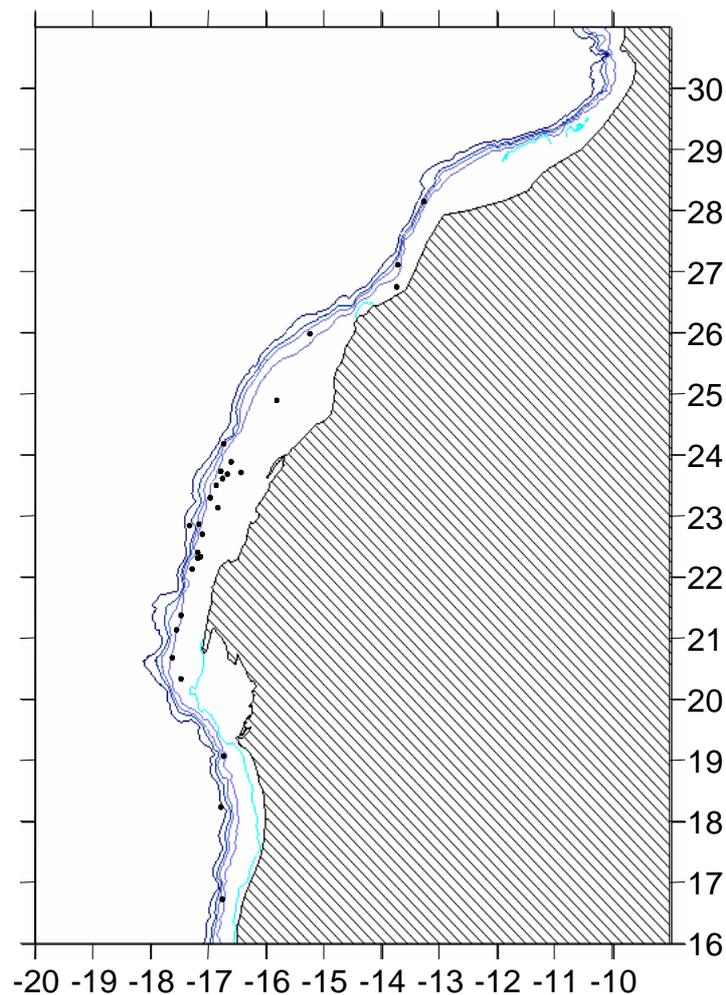


Fig. 17. Distribution of *I.oxyrinchus* by retrospective data.

Scyliorhinus canicula. The most frequent and abundant species at 25-300 m and common to 400 (Litvinov, 1993). Surprisingly it was not caught in 2005 survey. There is a gap in distribution from Gibraltar to 34°N, together with the morphological traits in teeth observed, it suggests the independent stock unit on Western African coast, of the subspecies and even species level (Litvinov, 2003). According to RD, it was dominant species at 25-300 m and common at 400 m depth. As usual, it forms separated aggregations of males and females, IRD ranged from 1 to 278, MV 49.2, SD 24.3. It readily feeds upon wastes from fish processing, forming even more dense aggregations of 225-675 IRD (Patokina, Litvinov, 2004). It is more common from 20 to 26°N, than northward and southward. There are several small gaps in distribution of about 30' latitude length (Fig. 20).

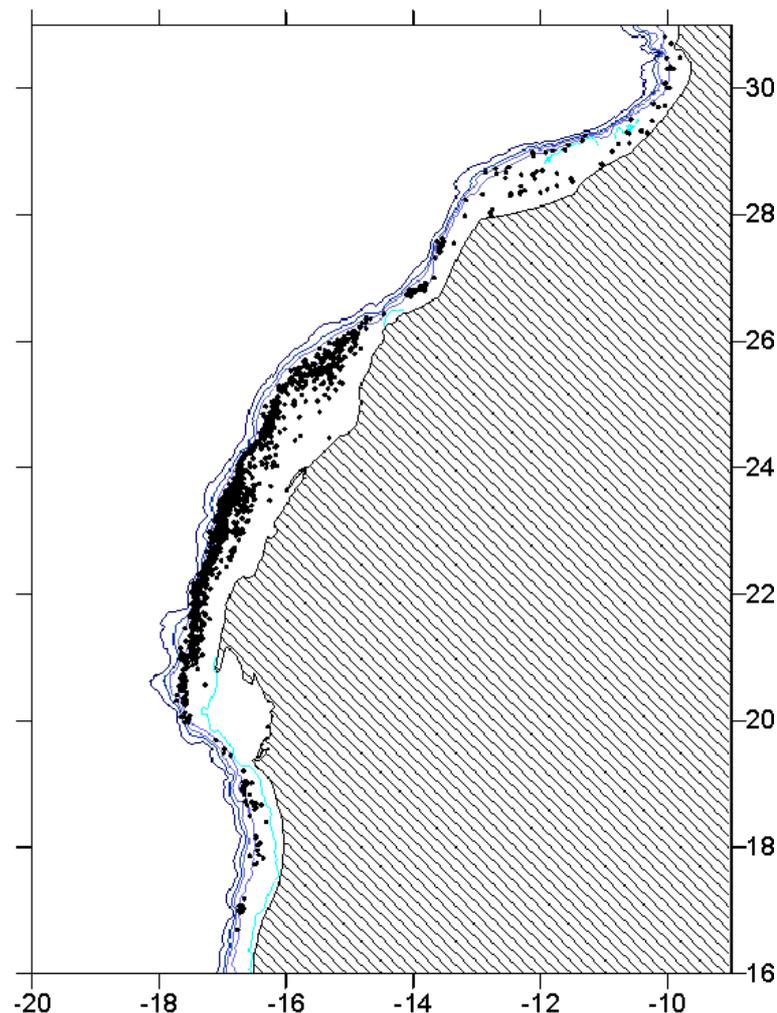


Fig. 18. Distribution of *S.canicula* by retrospective data.

Galeorhinus galeus. This species, abundant in some areas (Compagno, 1984), seems to be quite rare in the area considered: Litvinov (1993) did not mention it in Morocco nor in Sierra Leone; according to RD there were two captures only, at 26 and 29°N, 55 and 505 m depth. Collignon and Aloncle (1972) reported it as not very rare in Moroccan waters.

Leptocharias smithii. It was rather common from 16 to 20°30'N and sporadically caught northward to 28°30'N. Litvinov (1993) reported it as resident species at 50-100 m in Sierra Leone, but not in Moroccan waters. According to RD, it occurred from 10 to 230 m, mainly at

10-80 m depth; TL ranged from 60 to 89 cm (12 cm longer than reported Froese and Pauly, 2006).

Mustelus asterias. Compagno (1984) indicated its distribution northward 25°N, the fact fully corresponds to our retrospective data (Fig. 18). Litvinov (1993) mentioned it as rather common (subdominant) species at 50 m, and resident and subresident at 100-150 m. According to RD, depth ranged from 55 to 150 , TL 78-90 cm.

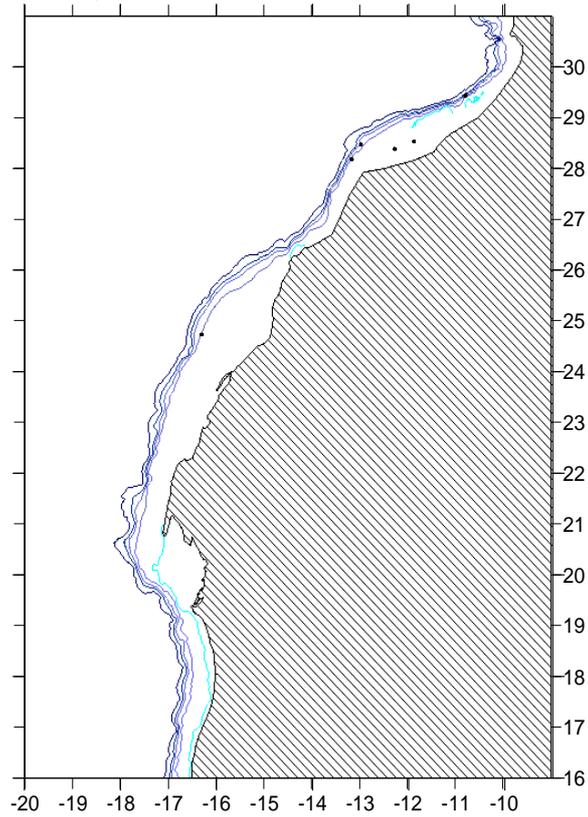


Fig. 19. Distribution of *M.asterias* by retrospective data.

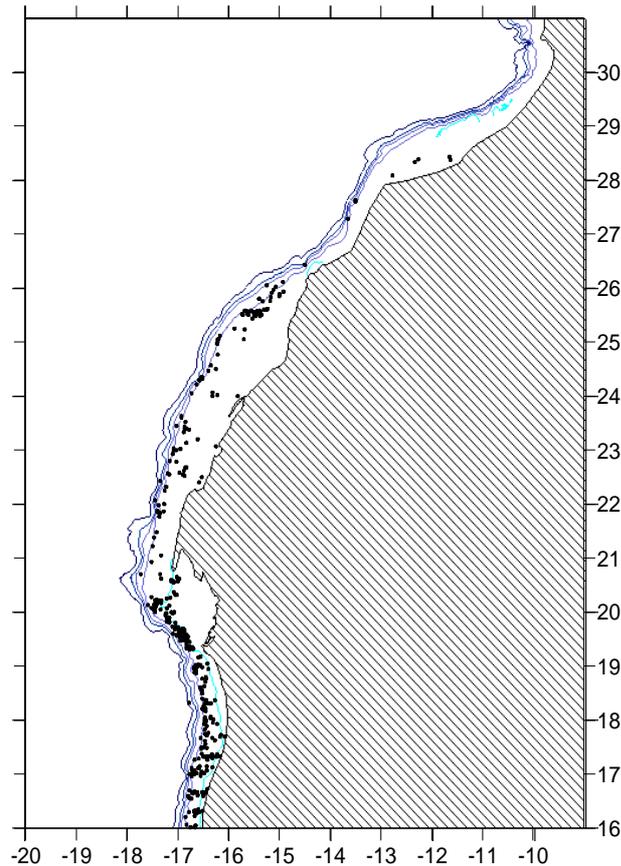


Fig. 20. Distribution of *M.mustelus* by retrospective data.

Mustelus mustelus. The species was more abundant comparing *M.asterias*. According to Litvinov (1993) it was found at 25-300 m depth, being more frequent (subdominant) at 50-75 m and less common deeper. According to RD it was more common southward 26°N, in contrary to *M.asterias* (Fig.19), being dominant at 10-25 m, subdominant at 50 and resident at 75-100 m. TL ranged from 36 to 147 cm, being mainly 75-90 cm.

Paragaleus pectoralis. It occurred from 16 to 21°N at 10-75 m depth. TL ranged from 35 to 95 cm, mainly 68-95 cm; IRD reached 45. Litvinov (1993) reported it in Sierra Leone at 10-75 m, in summer-autumn period southward 8°N, but not in Moroccan waters.

Prionace glauca. The most common and abundant oceanic shark in temperate and tropical waters (Compagno, 1984, Litvinov, 2006). It spends first years of life in coastal waters and forms aggregations, being endangered by artisanal gillnet fleet (see *Sphyrna lewini* here below). These young sharks of 49-135 cm TL were sporadically caught by bottom trawl along all the area at the depths of 16-678 m, mostly 25-150 m, Conception Bank included (Fig. 21).

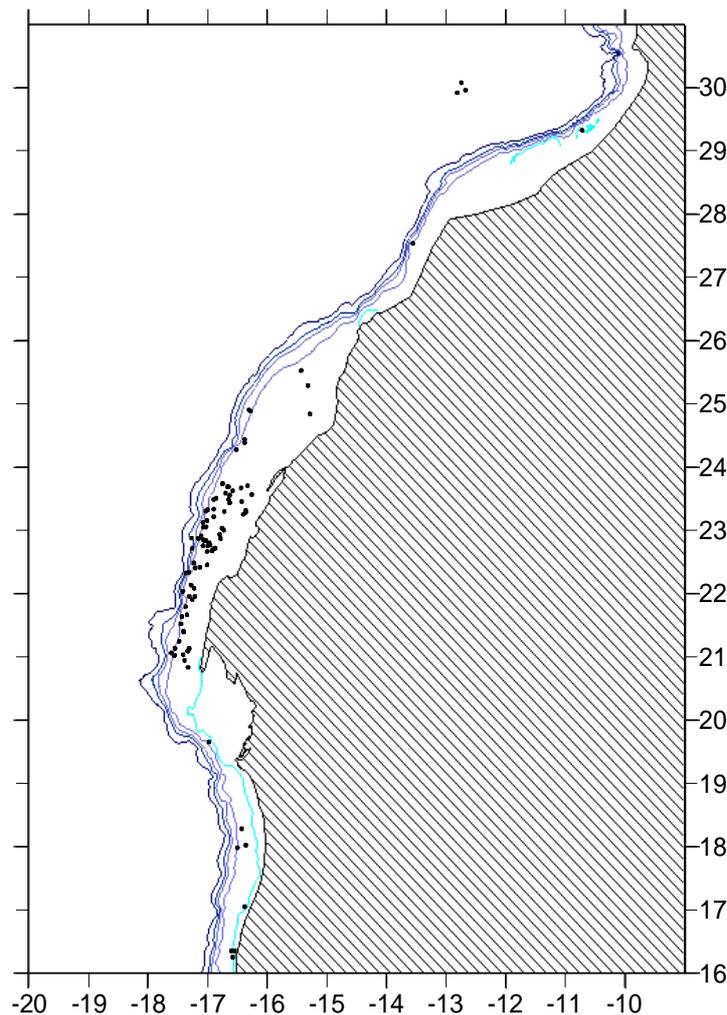


Fig. 21. Distribution of *P.glauca* by retrospective data.

Rhizoprionodon acutus. It occurred mainly southward 20°N and just once was found on 29°N, corresponding to map given by Compagno (1984). Litvinov (1993) mentioned one capture only at 100 m depth in Moroccan waters, but it was dominant species in Sierra Leone waters at

10-75 m. In 2006 June (pers. obs. Litvinov) *R.acutus* was one the main elasmobranch species fished by artisanal gillnet fleet southward Dakar.

Sphyrna couardi. It occurred from 18 to 23°30'N at 15-165 m depth. TL ranged from 68 to 95 cm, confirming that the nursery grounds were fished (see *S.lewini*).

Sphyrna lewini. Compagno (1984) reported it to be probably the most abundant hammerhead, coastal-pelagic species; young sharks primarily occur close inshore. Litvinov (1989) mentioned it in waters adjacent to Sao Tome Is. and in tropical coastal waters of Western Africa. According to RD, it was caught by bottom trawl from 16 to 21°N, with pronounced gap from 17°30' to 17°30'N (Fig. 28). There were caught mainly newborn and young sharks of 52-65 TL, at 15-220, mainly 15-135 m depth; IRD ranged from 1 to 38. Like other oceanic and semioceanic species (Litvinov, 2004; 2006) *S.lewini* spawns and spends first years of life in inshore waters, forming dense schools. These schools are endangered from artisanal gillnet fishery, which is highly developed in Western Africa. Such danger was confirmed by the following observation: in 2006 June (pers. obs. Litvinov) at village fish market there were observed circa 30 newborn *Sphyrna lewini* of about 40-45 cm TL, caught by gillnet in the nearest coastal waters at the depth of no more 100 m southward Dakar.

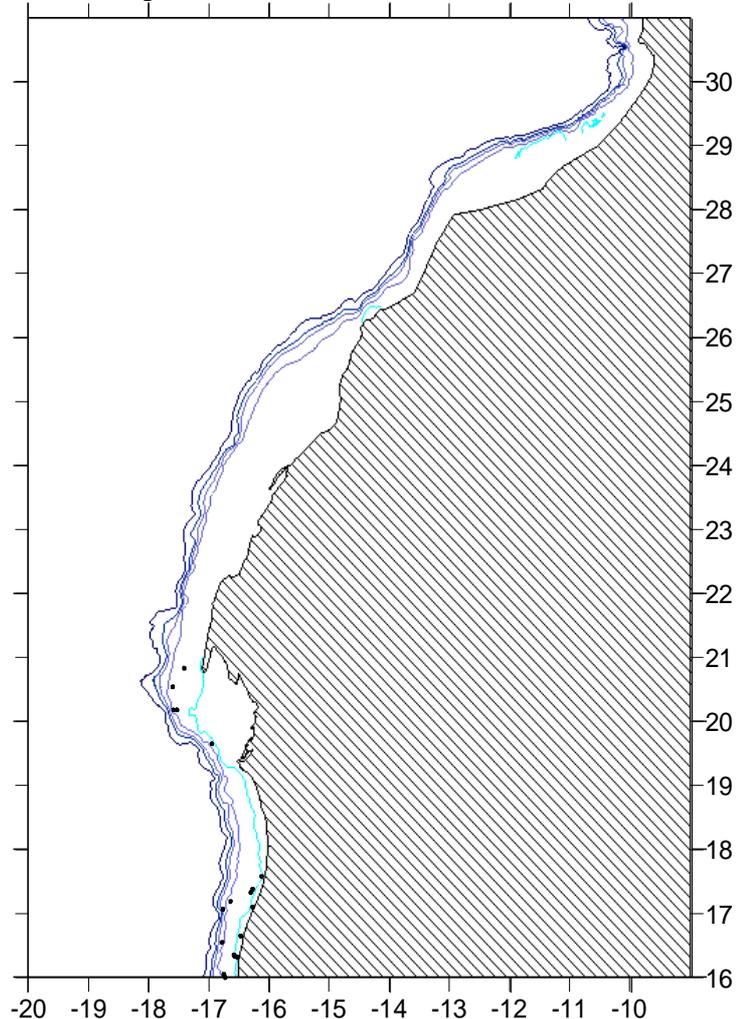


Fig. 22. Distribution of *S.lewini* by retrospective data.

Sphyrna mokarran. Despite of the dense investigations carried out by longline in the area in 1978-1986 (Litvinov, 1989), and many species considered, it has been never found, and so it was rare species that time. *S.tudes* in Collignon et Aloncle (1972) was most probable *S.mokarran*, it was mentioned to be rare in Moroccan waters and occasionally caught by

longline. However according to RD, it was caught by bottom trawls at the depths of 17-102 m from 17 to 23°30'N. There were caught 5 specimens in total, ranged from 111 to 154 cm TL, i.e. subadult ones. So, there were fished the nursery grounds or “kindergartens” described for the blue shark *Prionace glauca* (Litvinov, 2004, 2006). Like other oceanic and semioceanic species, hammerhead sharks spend first years of life in coastal waters, where young specimens are extremely endangered from artisanal undecked gillnet fleet (see *S.lewini*).

Sphyrna zygaena. Compagno (1984) reported it as coastal-pelagic and semioceanic species. According to distribution reported in Litvinov (1989) longline data, it is more oceanic comparing *S.lewini*. According to RD, there were caught specimens 40-198, mainly 40-110 cm TL, at 14-760, mainly 14-100 m depth. So, there is a nursery ground or “kindergarten” (see here above *P.glauca* and *S.lewini*) at 40-100 m from 17 to 31°N (Fig. 29). IRD ranged from 1 to 24. Comparing to nursery grounds of *S.lewini* and *S.mokarran*, restricted to tropical waters, that of *S.zygaena* is extended to temperate waters, as species as a whole; enormous migrating schools of young sharks of 1.5 m or less long are known from eastern Cape of South Africa (Compagno, 1984).

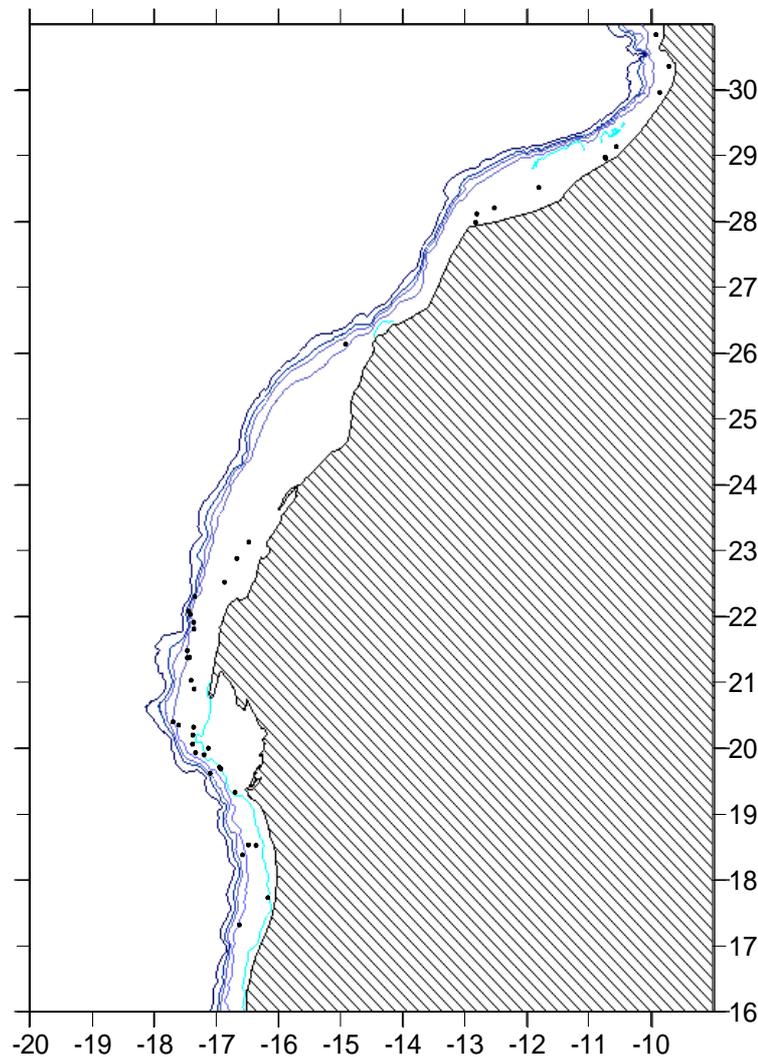


Fig. 23. Distribution of *S.zygaena* by retrospective data.

Dasyatis centroura. Collignon et Aloncle (1972) indicated its possible presence at Moroccan southern waters. Litvinov (1993) mentioned it in Sierra Leone waters only, as rare species at 10 and 12 m depth. According to RD it was not abundant, but rather common upper

shelf species, inhabiting or visiting Conception Bank (Fig.16). It was commonest from 20 to 25°N, and demonstrated gaps in distribution from 18 to 20°N and from 25°30'N to 27°30'N.

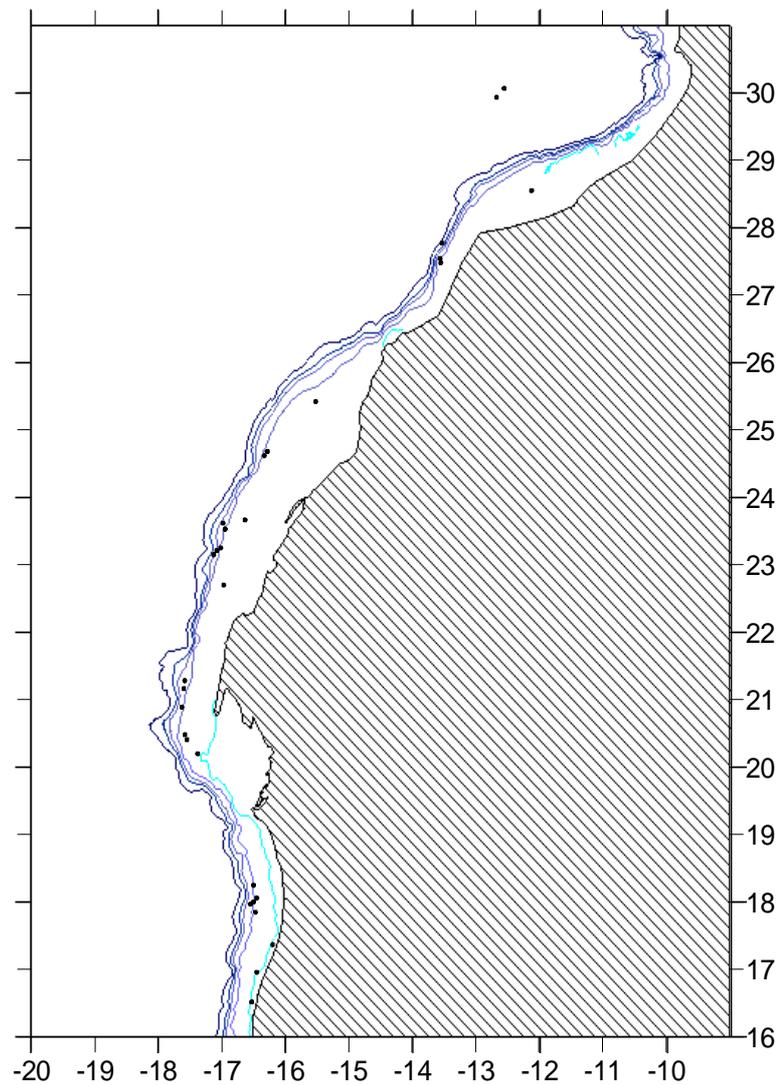


Fig. 24. Distribution of *D. centroura* by retrospective data.

Dasyatis margarita. The species occurred southward 25°30', corresponding to map given in Fischer and Bianchi (1981). According to Litvinov (1993), it was absent in Moroccan waters and dominant species in Sierra Leone at 10 m depth, being of the resident level only at 25 m and never found deeper. It forms aggregations, IRD ranged from 1 to 80, MV 47.8, SD 33.6. Like *R. acutus* (see here above), it is one of the most important species for the artisanal coastal fishery southward Dakar. The same time, it is often confused with *D. margaritella*, very similar species which was not listed in FAO regional guide (Fischer and Bianchi, 1981) as it was described in 1984.

Dasyatis pastinaca. It was noted as subdominant species in Moroccan waters at 50-100 m depth. Its absence northward 32°N suggests independent Western African stock unit (Litvinov, 1993). According to RD base, it occurred from 19°30' to 29°30'N, being rare species of the low abundance (IRD =1). It was not found in Sierra Leone, corresponding to the map given in Fischer and Bianchi (1981).

D. violacea. This common oceanic species (Litvinov, 1989) was sporadically caught over shelf and slope at 30-785 m depth.

Gymnura altavela. Collignon et Aloncle (1972) mentioned it as rare species in Moroccan waters, and Lloris et Rucabado (1998) as well. It was not mentioned in Litvinov's (1993) review. According to RD it occurred southward 26°N and was commonest from 16 to 20°N (Fig.17).

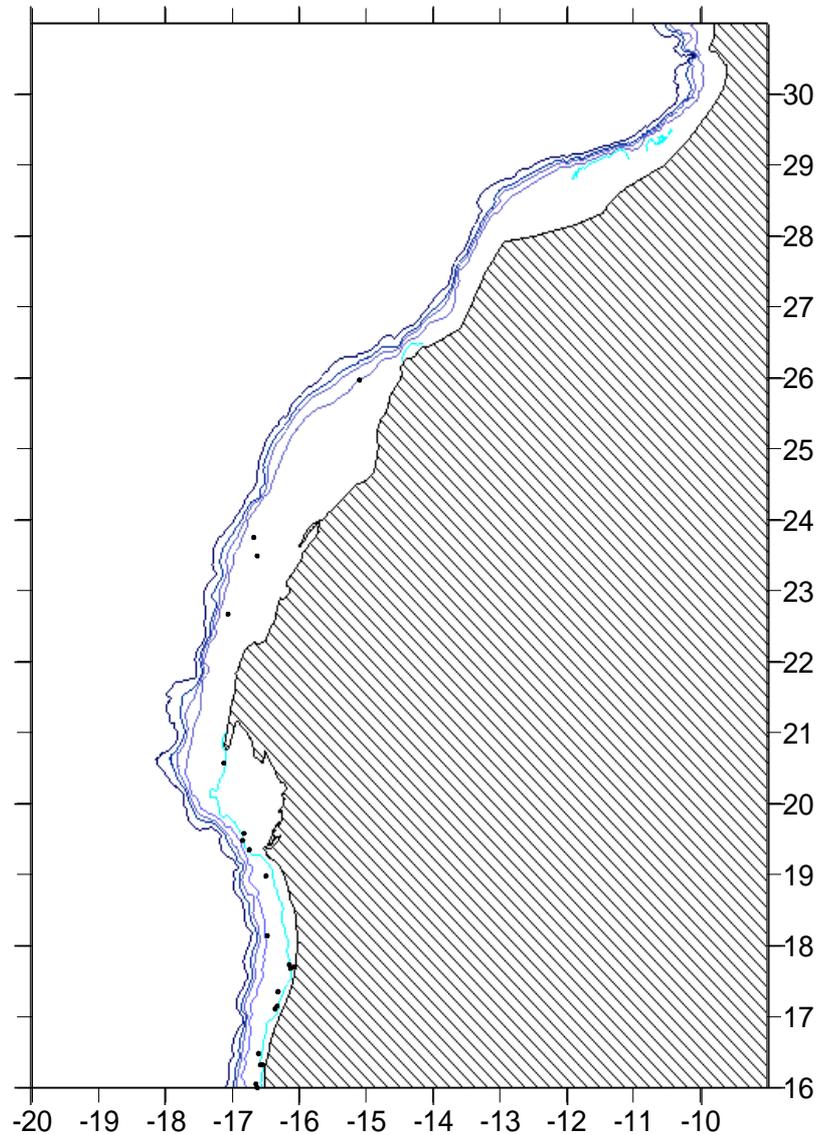


Fig. 25. Distribution of *G.altavela* by retrospective data.

Myliobatis aquilla. There were several sporadic captures from 18 to 27°N at 20-135, mainly 20-32 m depth. Litvinov (1993) reported one capture at 25 m depth in Sierra Leone, but not in Moroccan waters.

Pteromylaeus bovinus. It occurred from 16 to 20°N, mostly to 18°N at 12-36 m depth. IRD ranged from 1 to 4. Litvinov (1993) reported it in Sierra Leone at 10-25 m, but not in Morocco.

Rhinoptera bonasus. It sporadically occurred from 16 to 18°N at 12-25 m depth. IRD ranged from 2 to 38. Litvinov (1993) reported one capture in Sierra Leone at 20 m, together with *R. marginata*.

Rhinoptera marginata. It occurred from 16 to 20°N at 21-143, mainly 21-33 m depth. IRD ranged from 1 to 12.

Rostroraja alba. Occurred from 20 to 28°30'N at 150-200 m, rare species of low density (IRD =1). Litvinov (1993) mentioned it as are (resident) at 50 m depth.

Raja asterias. It is widespread species in the area. Litvinov (1993) mentioned its occurrence at 25-300 m, it is subdominant species at 100 and 150 m, however, IRD was low, 1-6. According to RD, IRD ranged from 1 to 5, MV 1.4, SD 1.2. It inhabits or visits Concepcion Bank. It is more common northward 20°30'N (Fig. 22).

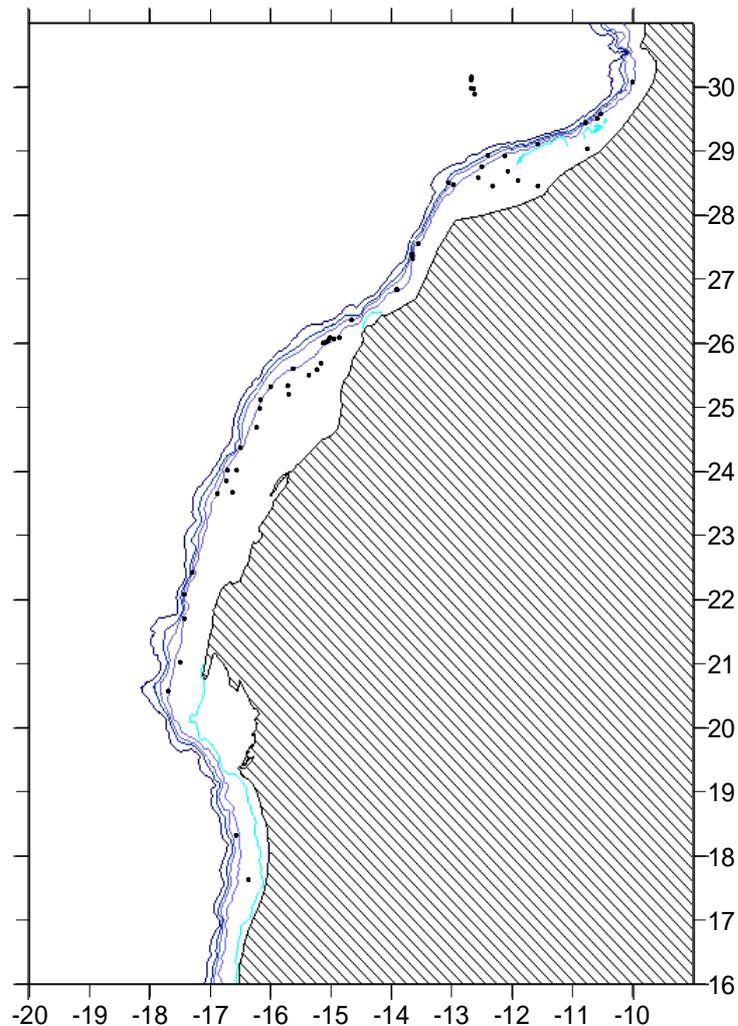


Fig. 26. Distribution of *R.asterias* by retrospective data.

Rajella barnardi. Froese and Pauly (2006) indicate its presence off Mauritania to South Africa, probably throughout on the deep, correspondingly it occurred mostly southward 23°N. Created aggregations up to 32 IRD.

Dipturus batis. Mostly single specimens, and sporadically aggregations up to 80 IRD were caught at 285-834 m depth. It was not mentioned in Litvinov (1993) for Morocco nor for Sierra Leone. Collignone and Aloncle (1972) noted its presence in Moroccan waters.

Leucoraja circularis. According to Froese and Pauly (2006) its distribution in Western Africa limited to Moroccan waters from 70 to 676 m depth. Litvinov (1993) mentioned it from

50 to 800 m, everywhere of the low occurrence. Collignon and Aloncle (1972) mentioned it as rare species of the Moroccan slope. According to RD it was never found southward $21^{\circ}30'$ and on coast northward $28^{\circ}30'N$, but Conception Bank only. IRD ranged from 1 to 11, MV 3.6, SD 4.0

Raja clavata. It is known as common species in Moroccan waters at 25-300 m, subdominant species at 100-200 m; the most abundant inside coral reef barrier at 200 m (Aloncle, 1970; Collignon, Aloncle, 1972; Litvinov, 1993). It was not found at Conception Bank, but observed on submarine mounts southward Azores (Kukuev, 2004). It was commonest from 20 to $26^{\circ}N$, there are pronounced gaps in distribution from 19 to $20^{\circ}N$ and from 24 to $25^{\circ}N$ (Fig. 23). IRD ranged from 1 to 34, MV 5.7, SD 12.5.

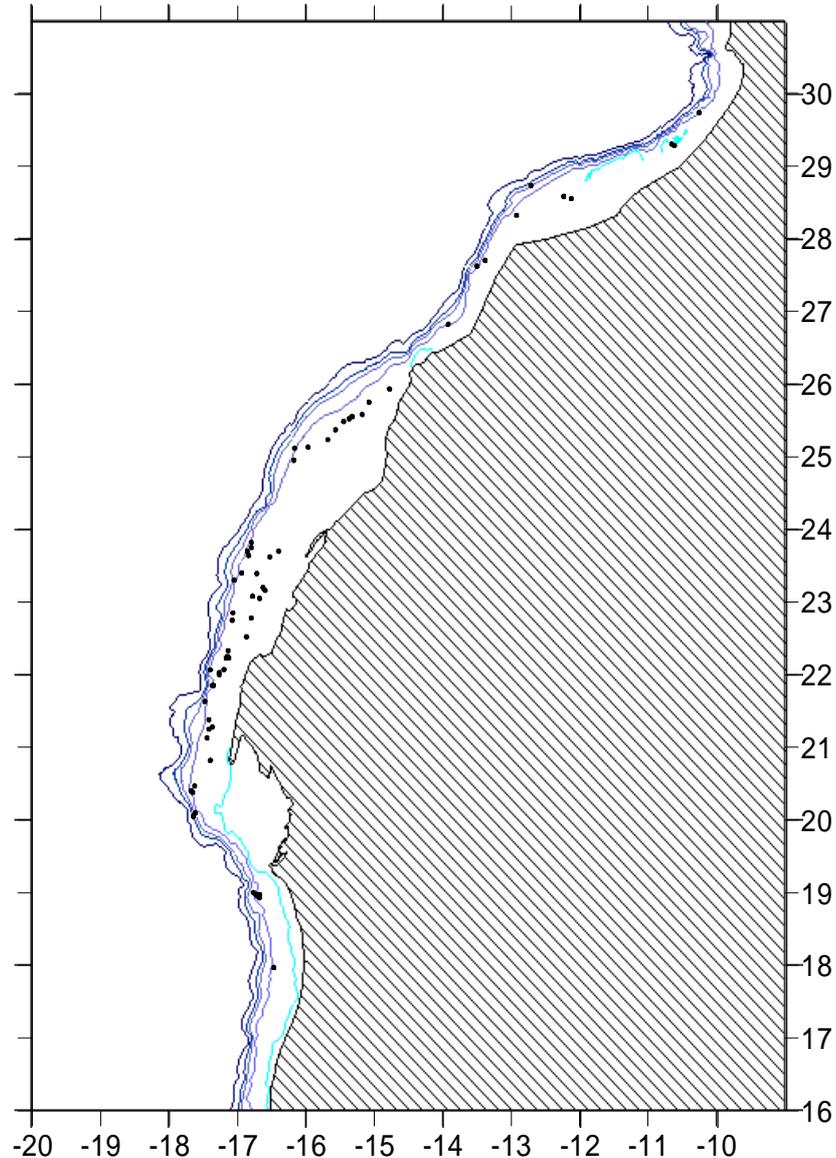


Fig. 27. Distribution of *R. clavata* by retrospective data.

Leucoraja fullonica. It is known from North Morocco (Froese, Pauly, 2006). Aloncle (1970) mentioned it as rare species in Moroccan waters. Litvinov (1993) mentioned it as rare (subresident) species at 100 m; it was found on Conception Bank 412 m.

Raja maderensis. Froese and Pauly (2006) suggest records from western Africa to be probably misidentifications. Litvinov (1993) reported species identified as *R. maderensis* to be rare (resident and subresident) species at 75-300 m depth in Moroccan waters. IRD ranged from 1 to 43, MV 8.2. According to RD base, it was found from $22^{\circ}30'$ to $26^{\circ}N$, and on the Conception Bank at 365 m.

Raja microocellata. It was not found northward 34°N, (Litvinov, 1993) and absent in Mediterranean (Froese, Pauly, 2006) so local western African stock unit may be suggested, different from European one. It was noted as subresident and resident species at 25-300 m, Aloncle (1970) reported it preferring depths less 100 m. The distribution is spotted, from 22 to 25°N and northward 28°N. IRD ranged from 2 to 30 (at 100 m), MV 6.3.

Raja miraletus. This is one of the most abundant elasmobranchs of the Western African coast. Litvinov (1993) reported single specimen captures at 25-200 m, evenly distributed along Moroccan coast. It was more abundant southward, in Sierra Leone, being a dominant or subdominant species at 25-300 m; however, it was absent at 10 m depth, most probable due to temperature preferences. In general it is more common southward 26°N, and there is a pronounced gap between 26 and 27°N (Fig. 24). IRD ranged from 1 to 65, MV 12.2, SD 8.1. It was found on Conception Bank.

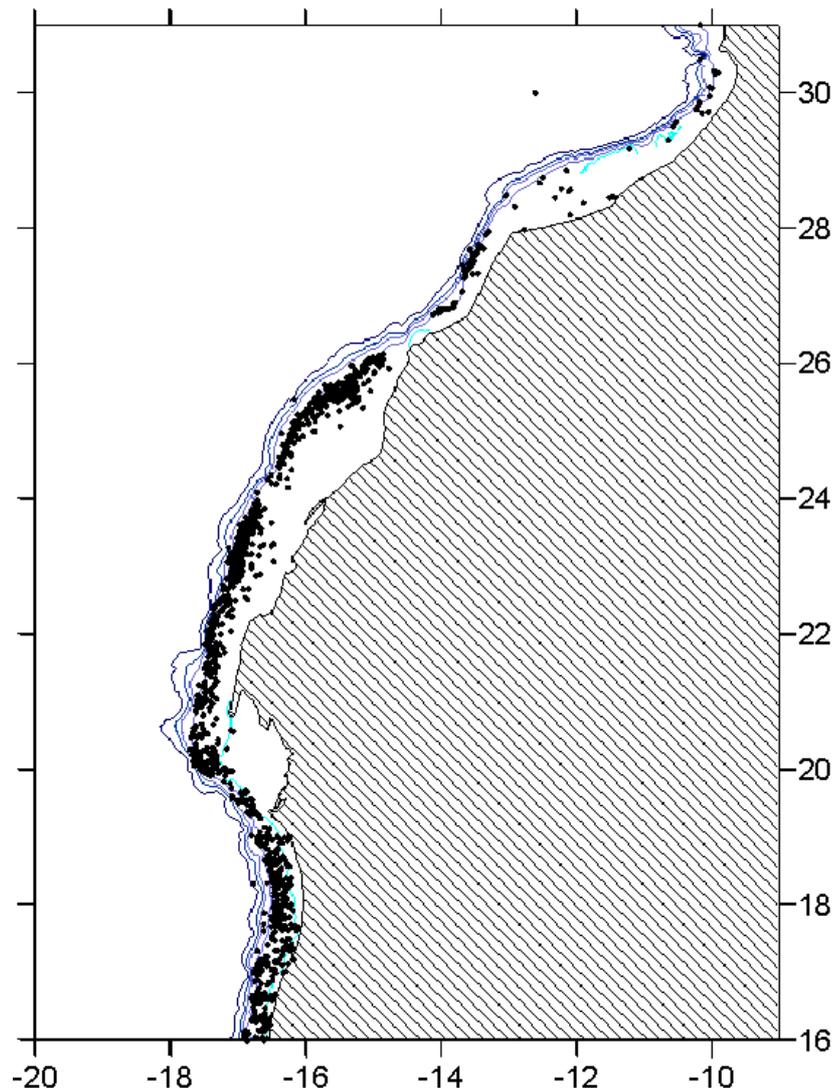


Fig. 28. Distribution of *R.miraletus* by retrospective data.

Leucoraja naevus. In Moroccan waters it occurred at 50-400 m depth, being commonest (subdominant) at 150 m (Litvinov, 1993) and never found northward 34°N, thus separated stock unit in Western Africa may be suggested. The distribution pattern is spotted, the species was found from 21°N to 26°30'N and from 28°30'N to 30°N (Fig. 25). IRD ranged from 1 to 30, MV 7.0, SD 6.1.

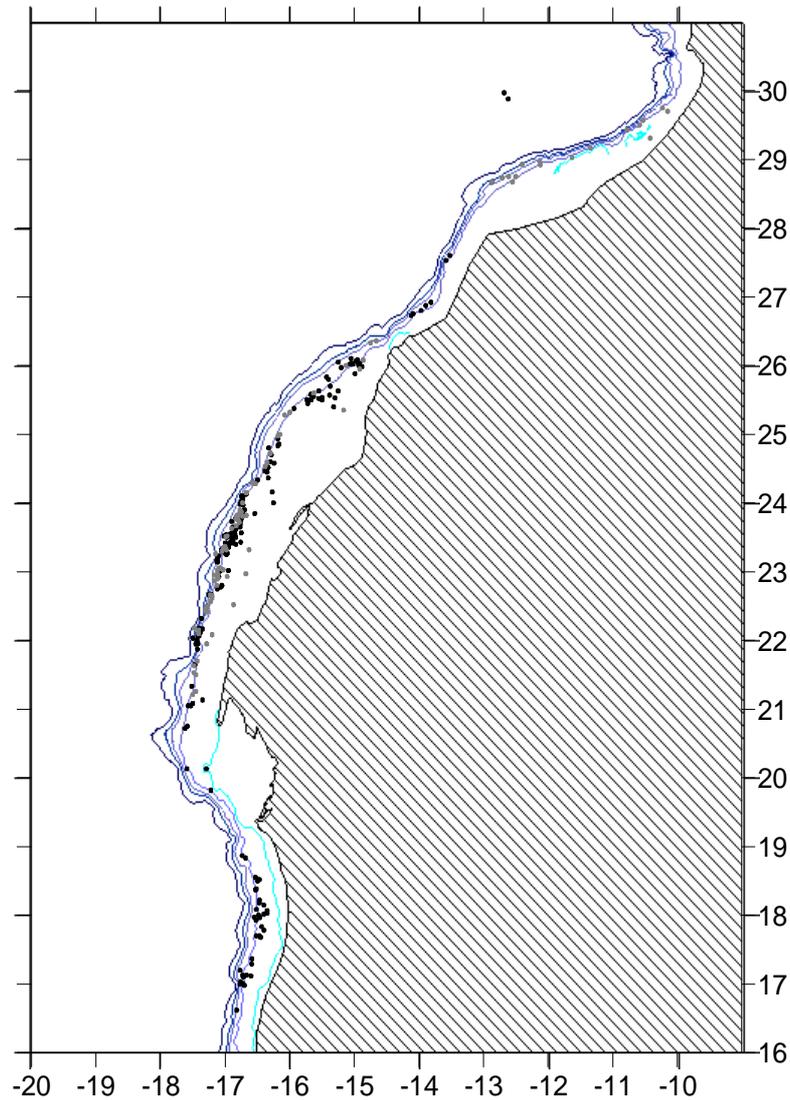


Fig. 29. Distribution of *L.naevus* (grey circles) and *R.radula* (black circles) by retrospective data.

Dipturus oxyrinchus. There were reported two captures in Moroccan waters, at 220 and 810 m (Litvinov, 1993). Collignon and Aloncle (1972) mention captures by longline. According to RD, it was sporadically caught from 17 to 31°N at 200-300 and 800 m.

Raja radula. Froese and Pauly (2006) believes some Atlantic records of this species probably misidentifications of *Raja naevus* and/or *Raja africana*. It is possible, but in some cruises the two species (*R.naevus* and *R.radula*) were recorded; *R.africana* was never identified. The distribution patterns were some different (Fig. 25): the species identified as *R.radula* was never found on shelf and slope northward 28°30', but on Conception Bank. Litvinov (1993) did not report *R.radula*, Collignon and Aloncle (1972) suggest penetration of *R.radula* to Atlantic coast of Morocco. *R.radula* is mentioned in Schneider (1990) for Gulf of Guinea.

Raja straeleni. According to Froese and Pauly (2006) the depth range of this species is 80-800 m; Litvinov reported it as resident and subsresident species at 25-100 m in Moroccan waters. According to RD it was found mostly at 16-23°30'N, once at 26°N and on Conception Bank; from 50 to 640 m, with no pronounced preferences. IRD ranged from 1 to 63.

Raja undulata. It was distributed from 17 to 30°N, mainly from 17 to 26°N. Litvinov (1993) reported it as rare (resident and subresident) species at 25-75 m in Moroccan waters. Alongle (1970) noted seasonal migrations (Fig. 26). IRD ranged from 1 to 9, MV 5, SD 5.6.

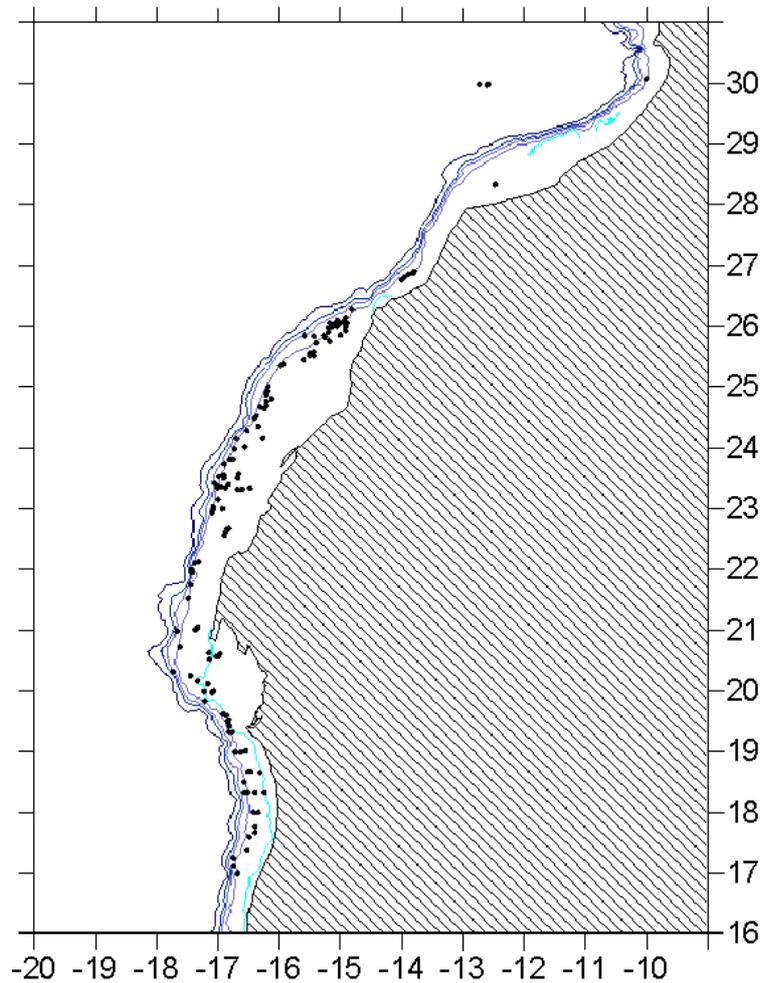


Fig. 30. Distribution of *R.undulata* by retrospective data.

Rhinobatos albomaculatus. It occurred sporadically from 16 to 21°N at 20-53 m depth. IRD ranged from 1 to 14. Litvinov (1993) reported it as rare (resident and subresident) species at 10-50 m in Sierra Leone.

Rhinobatos cemiculus. It occurred from 16 to 21°N, at 14-40 m depth. The maximum TL reached 240 cm. Litvinov (1993) reported one capture in Moroccan waters at 50 m. IRD ranged from 1 to 4.

Rhinobatos rhinobatos. It occurred from 16 to 22°30'N, mainly to 18°30'N, at 10-100, mainly 10-60 m depth. Litvinov (1993) reported it as common (subdominant) species in Sierra Leone at 10-100 m depth, but not in Moroccan waters. IRD ranged from 1 to 63.

Zanobatus schoenleinii. It occurred southward 20°30'N (Fig. 31) at 10-60 m depth. IRD ranged from 1 to 57, aggregations were rather frequent. TL ranged from 28 to 57 cm. Litvinov (1993) reported it at 10-25 m in Sierra Leone, but not in Morocco. TL ranged from 28 to 57 cm.

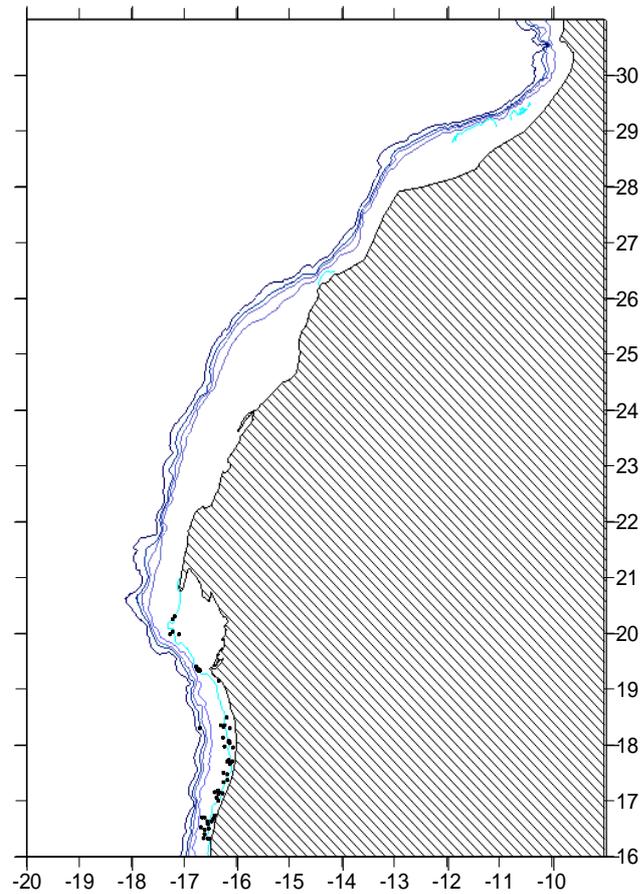


Fig. 31. Distribution of *Z. schoenleinii* by retrospective data.

Torpedo marmorata. It was found through the area from 16 to 31°N; the pronounced gap was revealed from 19 to 21°N. It occurred from 12 to 435 m depth. Litvinov (1993) reported it as dominant species at 25 m and resident and subresident at 50-200 m depth in Moroccan waters. The maximum measured TL was 67 cm.

Torpedo nobiliana. It occurred from 16 to 19°N and at 23°N, in accordance with distribution given in Froese and Pauly (2006), at 12-400 m depth. IRD ranged from 1 to 26. Litvinov (1993) mentioned it as subresident species at 200-400 m depth.

Torpedo torpedo. The species was distributed from 16 to 25°30'N, with no pronounced gaps in distribution, at 10-320 m depth (Fig. 30). IRD ranged from 1 to 56, maximum measured TL 55 cm. Litvinov (1993) reported it as resident and subresident species at 25-50 m in Moroccan waters and at 10-100 m in Sierra Leone.

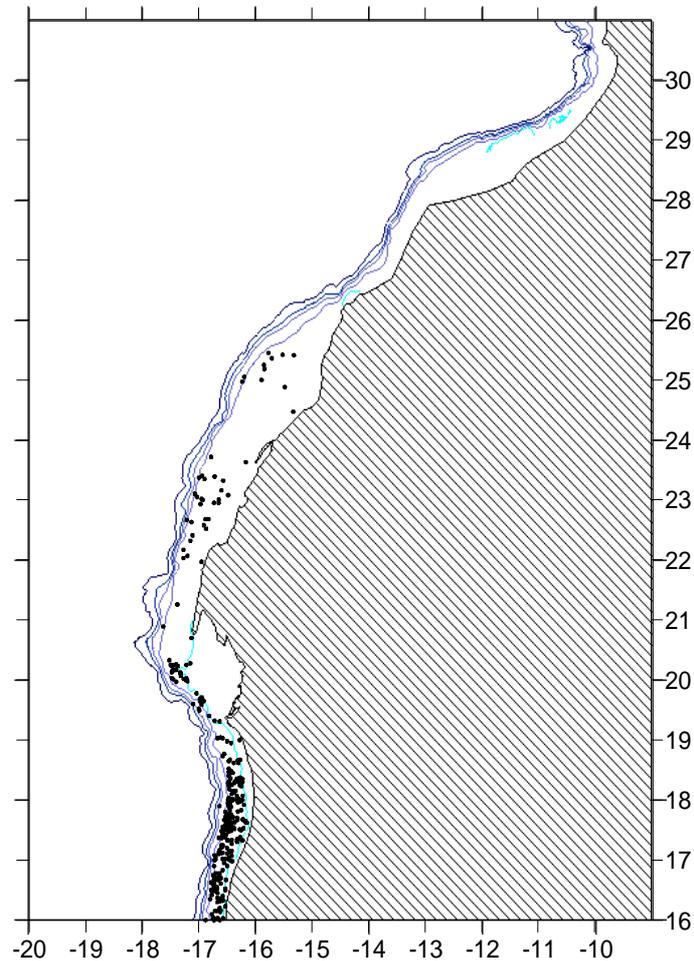


Fig. 32. Distribution of *T. torpedo* by retrospective data.

DISCUSSION

Quantitative assessment

The special demographic parameters were not used in the present paper to evaluate the states the state of species populations. However, comparison of the quantitative indices applied, Relative Frequency Occurrence and Index of the relative abundance, allow conclude on the abundance of the species in general. When comparing RFO and IRD, it may be concluded, that these indices describe species frequency and abundance parameters in the similar way, the abundant species are mostly more common in the terms of occurrence (Fig. 33; 34.). There is some difference in the species order: e.g. *Etmopterus spinax* is the first in IRD order, and 6th in the terms of occurrence (RFO), however, it is common and abundant (of the dominant and subdominant level) species in both cases. At it was demonstrated (Litvinov, 1993), when considering abundance and occurrence in narrower ranges, the species order is very similar for both IRD and RFO. As it is clear from the species description given in RESULTS and histograms of RFO and IRD here below, for the most species inhabiting depths 300-900 m, common and abundant (*E. spinax*, *D. profundorum*, *D. calcea*, *S. squamosus*, *S. obscurus*, *S. ringens*, *C. granulatus*, *Galeus spp.*) and rare as well (*Ch. anguineus*, *H. perlo*), no drastic changes were observed (Fig. 35; 36). These species were of the same level of frequency and abundance in 2005 as according to retrospective data and literature sources (Collignon, Aloncle, 1972, Litvinov, 1993) or even higher (*C. squamosus*).

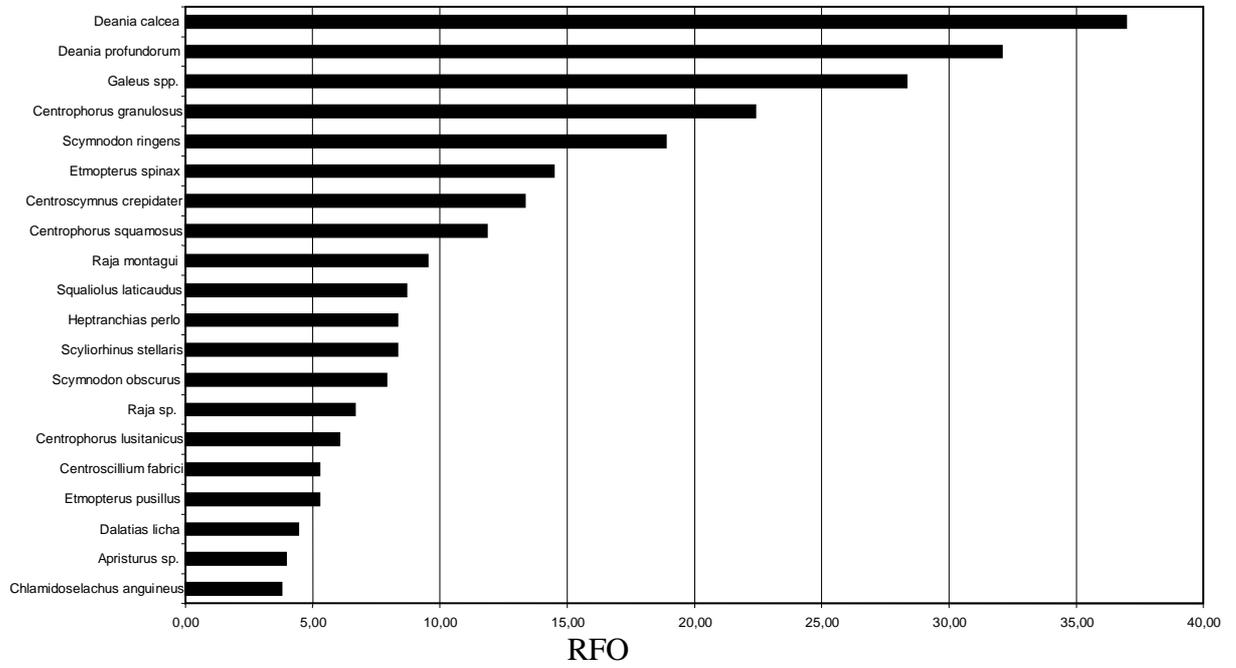


Fig. 33. Relative Frequency Occurrence of elasmobranch species at 300-900 m depth by 2005 data.

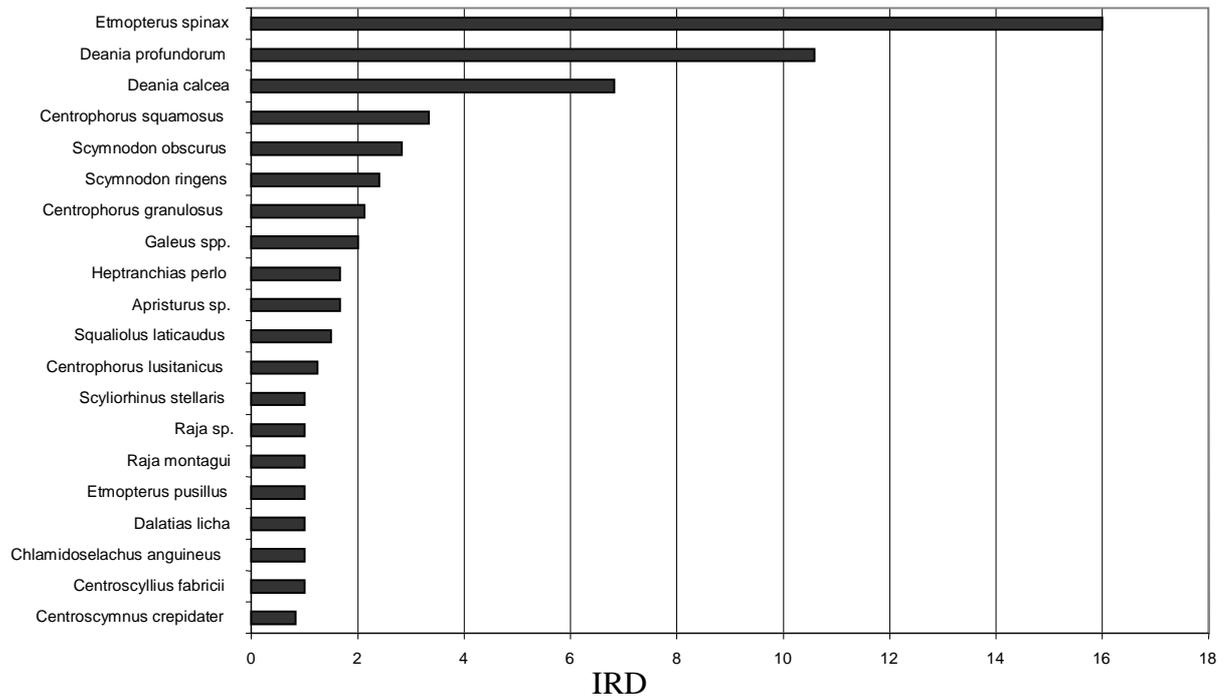


Fig. 34. Index of the Relative Density of elasmobranch species at 300-900 m depth by 2005 data.

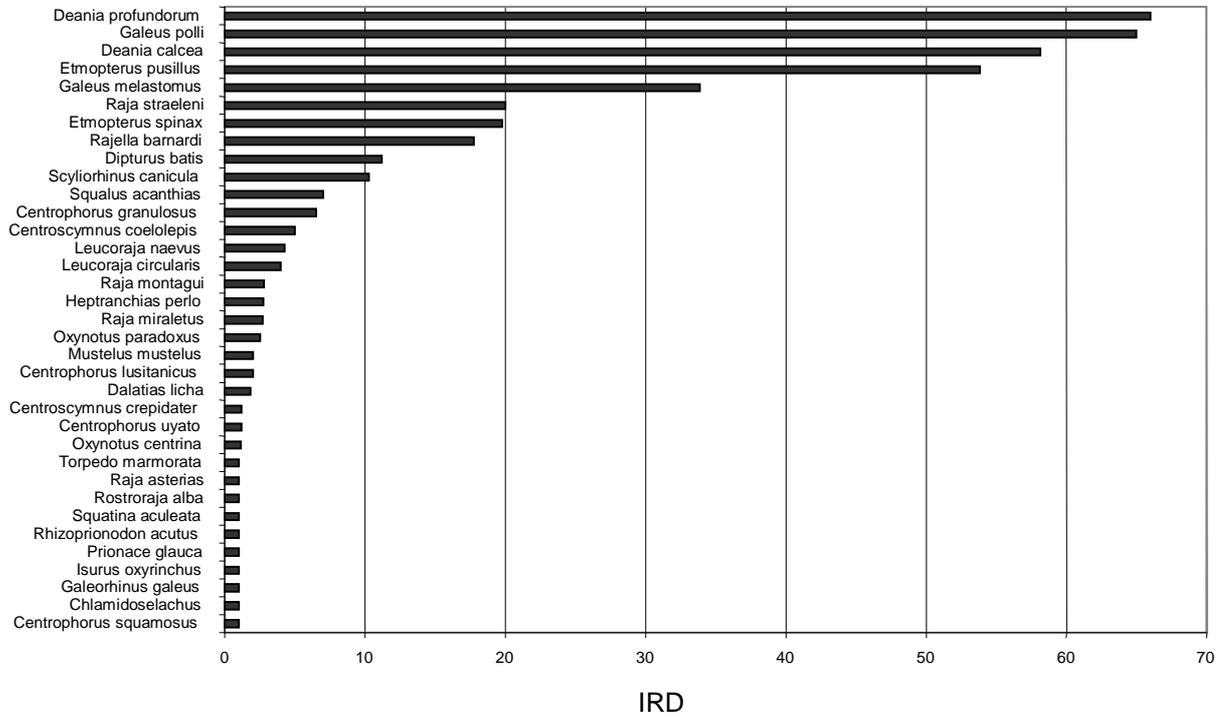


Fig. 35. Index of the Relative Density of elasmobranch species at 300-900 m depth by retrospective data.

Etmopterus pusillus was significantly less frequent and abundant in 2005 comparing retrospective data. It cannot be artifact due to misidentification, as both species were caught together in many cruises in the past and by the first author in 2005 as well. As the species was distributed mainly from 22 to 27°N, its absence may be due to the same environmental factors caused the changes in distribution of *E.spinax*, *D.calcea* and *C.granulosus* (see species description above and Distribution patterns here below).

Centrophorus uyato. Its absence in 2005 is unclear, possibly due to some environmental events caused gaps in distribution of *C.granulosus*. However, as it was assessed as quite rare species in the past, its absence may be due to random factor.

The histogram of Index of the Relative Density of elasmobranch species at 10-200 m depth by retrospective data is presented at Fig. 36.

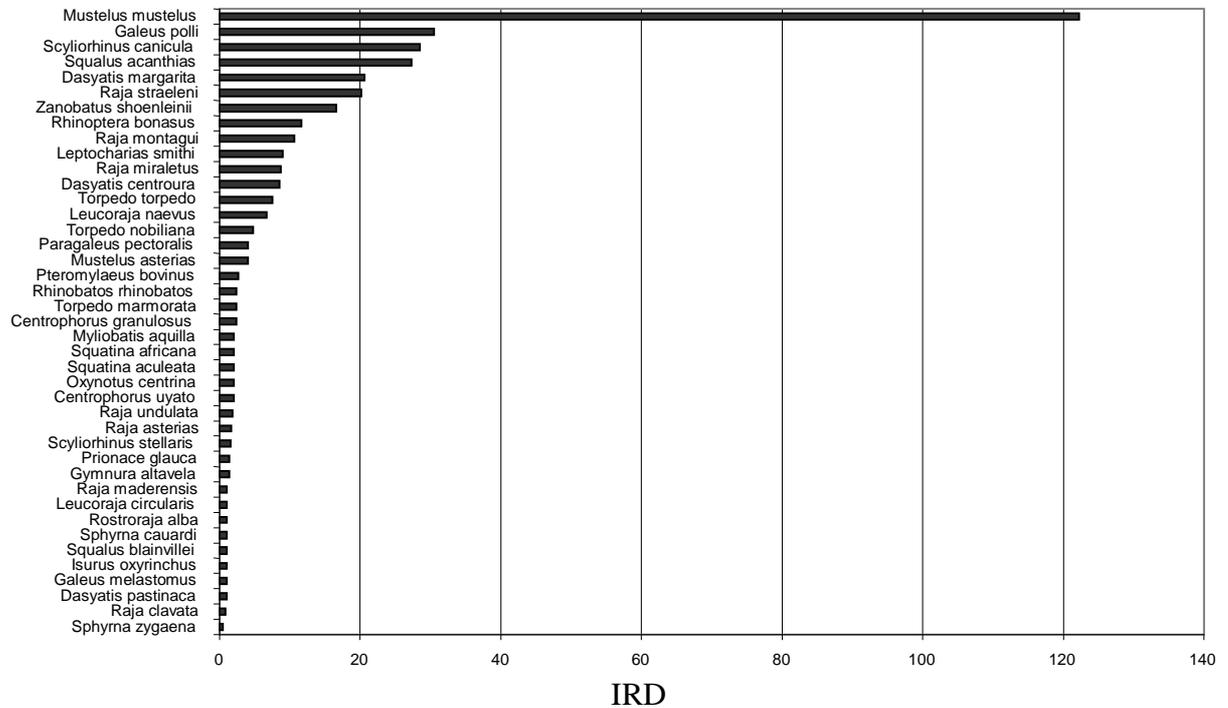


Fig. 36. Index of the Relative Density of elasmobranch species at 10-200 m depth by retrospective data.

Distribution patterns.

The distribution patterns (DB) are very important for intraspecies structure understanding and stock units' delimitation. It was found, that gap in distribution of elasmobranchs northward $32-34^{\circ}\text{N}$, caused by interaction of currents and watermasses, separates western African species from western European and Mediterranean ones (Litvinov, 1993; 2003; Litvinov, Kudersky, 2004).

The most stable gap revealed in the above species descriptions is situated between 19 and 20°N . This gap was found in the new and retrospective data, for many species: *D.profundorum*, *D.calcea*, *E.spinax*, *O.centrina*, *R.naevus*, *T.marmorata*. From other side, the gap was absent in distribution of *C.granulosus*, *Galeus melastomus*, *R montagui*, *D.margarita*, *G.altavela*, *L.smithii*, *M.mustelus*, *P.pectoralis*, *R.miraletus*, *L.straelenii*, *R.undulata*; *S.canicula* was significantly less abundant there comparing other parts of the area. As it is seen, the gap is mainly respected by slope species than shelf ones, however, it is presented in distribution of shelf *L.naevus* and *M.mustelus* and absent in slope *G.melastomus*. The position of the gap correspond to the position of frontal zone between the main water masses of the Central East Atlantic: Northern Atlantic Central Water Mass and Southern Atlantic Central Water Mass (Fraga et al., 1985; Llinas et al., 1985). One may suggest the genetic exchange between parts of the species range southward 20°N and northward 19°N to be significantly decreased or absent, and so existence of isolated stock units for *D.profundorum*, *D.calcea*, *E.spinax*, *O.centrina*, *R.naevus*, *T.marmorata* seems to be very probable. As it shown (Litvinov, 1993) elasmobranchs are quite sensitive to the boundaries between water masses.

The other species were presented only in southern (*D.margarita*, *G.altavela*, *I.oxyrinchus*, *M.mustelus*, *P.pectoralis*, *P.bovinus*, *Rhinobatos spp.*, *R.bonassus*, *R.marginata*, *T.torpedo*, *D.lichia*) or northern (*E.pusillus*, *D.pastinaca*, *L.circularis*) parts of the area considered, suggesting so independent stock units northward or southward.

The other gap was found between 24 and 27°N. This gap existed permanently in *D.profundorum*; *D.calcea* was found there in 2005 only, and *C.granulosus* was presented there in the past and not found in 2005. So, the phenomenon of the antifase does exist in the presence of *C. granulosus* and *D. calcea* between 25 and 27°N. The presence of some gap here was found in *S.acanthias*, *E.spinax*, *S.stellaris*, *S.obscurus* and *S.ringens*. Most probable, this gap is due to fluctuations of the Canary Subsurface Current (Mittelstaedt, 1982).

Conception bank.

It was revealed (Litvinov, 1993), that some shelf and slope species were presented on the Conception bank, westward 30°N: *O.centrina*, *R.maderensis*, *R.asterias*, *L.circularis*, *L.fullonica* and *G.melastomus*. The present study revealed presence of *C.crepidater*, *D.profundorum*, *E.spinax*, *C.granulosus*, *D.centroura*, *R.miraletus*, *L.naevus*, *R.straeleni*, *R.undulata*.

CONCLUSIONS

1. The species collected in 2005 did not reveal significant changes in occurrence and abundance, as it is clear from IRD and FRO values, but *Etmopterus pusillus*, most probable due to environmental changes.
2. The gaps in distribution patterns suggest stock units of intraspecific level. The small-scale structure of many species' ranges demonstrate complexity which is not fully understood yet. It is clear, that for the adequate species protection such knowledge is absolute necessary.
3. The distribution of several species (*D.calcea*, *D.profundoru*, *C.granulosus* etc.) in zone between 23 and 28°N suggest environmental changes of the long-period (m.b. cyclic) nature, related to currents and water mass movements. The deeper slope species are more sensible to such changes comparing shelf ones.
4. It was revealed, that young sharks of oceanic and semioceanic species, like *Isurus oxyrinchus*, *Prionace glauca*, *Sphyrna mokarran*, *S. zygaena*, *S. lewini* spends first years of life cycle in coastal waters. The schools of these sharks are heavily fished by coastal artisanal undecked gillnet fleet, and special protective measures are urgently required.

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