

# Composition and abundance of pelagic shark by-catch in the eastern Mediterranean Sea

by

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**ABSTRACT.** - During the period 1998-2001, a survey to study the incidence of the drifting longline fishery on shark populations was carried out in the eastern Mediterranean Sea. A total of 8 different pelagic shark species were recorded in the catches of the Greek swordfish and albacore longline fisheries. Among them, the blue shark, *Prionace glauca*, was the most common species in the catches while the bigeyed sixgill shark, *Hexanchus nakamurai*, was reported for the first time in the area. Shark by-catches were noteworthy in the swordfish fishery reaching a 3.8% in number and 3.6% in biomass of the total catch. The higher abundance indices were observed in the Levantine Basin (CPUE = 0.74 sharks/1,000 hooks). Catches in this area consisted of much larger specimens than those measured in other areas of the Mediterranean Sea.

**RÉSUMÉ.** - Composition et abondance des prises accessoires de requins pélagiques en Méditerranée orientale.

Une étude sur l'impact des pêches palangrières sur les populations de requins a été menée en Méditerranée orientale, entre 1998 et 2001. Au cours de cette étude, huit espèces de requins pélagiques ont été recensées dans les pêcheries palangrières grecques ciblées sur le germon (*Thunnus alalunga*) et l'espadon (*Xiphias gladius*). Le requin peau bleue, *Prionace glauca*, était l'espèce la plus commune dans les captures. En revanche, le requin-vache, *Hexanchus nakamurai*, a été signalé pour la première fois dans cette zone. Les prises accessoires de requins étaient relativement importantes dans la pêche ciblée sur l'espadon, atteignant 3,8% en nombre et 3,6% en biomasse de la capture totale. Les indices d'abondance les plus élevés ont été observés dans le bassin Levantin (CPUE = 0,74 requin/1000 hameçons). Les requins capturés dans cette zone étaient de plus grande taille que ceux qui sont pêchés dans les autres zones de la Méditerranée.

Key words. - Pelagic sharks - MED - By-catch - Size distribution - CPUE.

Among marine fauna, sharks are one of the less well-known groups, both in terms of biology and stock assessment. This fact seems to result from their low economical value and consequently low research priority in most fisheries institutes. However, this situation changed a lot recently due to an increase of public interest on shark conservation and management concern. Sharks are slow-growing species with long reproductive cycles, and it is not clear if any stock population can sustain heavy fishing mortality over many years (Castro *et al.*, 1999). Moreover, as the status of worldwide sharks stocks is generally unknown, there is worry that excessive removals of the top predators could have negative effects on predator-prey relationships in marine ecosystem. Some 50% of the estimated global catch of chondrichthyans taken as by-catch does not appear in official fishery statistics, and is almost totally unmanaged (Stevens *et al.*, 2000). Official catches usually report sharks, rays and chimaeras in a single group but shortage of analytical information by species is of great concern to the international scientific community. Pelagic sharks represent a large by-catch of global high-seas longline fisheries targeting tunas and billfish, and are retained primarily for their highly valued fins. There are currently few regulations for reporting their by-catch in the oceanic zone, which comprises mainly blue shark, *Prionace glauca* L., oceanic whitetip, *Carcharhinus longimanus*

(Poey, 1861), and silky shark, *Carcharhinus falciformis* (Müller & Henle, 1839) (Stevens *et al.*, 2000).

In the Mediterranean Sea, data on shark catches are rare. Although no pelagic shark directed fishery exists at present, due to their relatively low commercial prices, other large pelagic fisheries targeting mainly swordfish or tuna, catch sharks incidentally (De Metrio *et al.*, 1984; Filanti *et al.*, 1986; Di Natale, 1998; Buencuerpo *et al.*, 1998; Castro *et al.*, 1999; Mejuto *et al.*, 2002). Most of the recent data concern shark by-catch in the western Mediterranean Sea where the catch rates are high, especially in the Gibraltar Strait. Since the late 1960, a large pelagic fishery in the eastern Mediterranean Sea has been operating mainly by a Greek longline fleet targeting primarily swordfish (De Metrio *et al.*, 1988) and fishing in depths from the surface down to about 50 m. Up to date, however, there has been no information on the shark by-catch and consequently the amount of shark caught by longline fisheries in this area remains uncertain. Because fishermen generally do not keep logbooks to report daily catches, data on the occurrence of sharks are difficult to recover. In order to acquire information regarding the incidence of shark catches in the longline, a 4-year survey monitoring Greek swordfish and albacore longline fleets was performed. In this paper, we present the results obtained with on board and at landing observations. Our main objectives were

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to describe the composition and distribution of the various pelagic shark species caught incidentally in the eastern Mediterranean and to study their relative abundance using catch and effort data.

## MATERIALS AND METHODS

During a four-year period (1998-2001) sampling was carried out throughout the eastern Mediterranean Sea using a network of fishing ports in the Ionian Sea, the Aegean Sea and the Levantine Basin (Fig. 1). Data were obtained from records taken by observers stationed both at pilot fishing ports and onboard commercial fishing vessels targeting swordfish, *Xiphias gladius*, or albacore, *Thunnus alalunga*. Three types of fishing gears were sampled: traditional swordfish longline (SWO-LL<sub>T</sub>), American type swordfish longline (SWO-LL<sub>A</sub>) and albacore longline (ALB-LL). Traditional swordfish longline consists of a nylon monofilament main line from 2 to 3 mm Ø in cross section hung in a sagging curve between surface floats. Branch lines with a length from 5 to 18 meters descend from the main line, each terminating with a single baited hook. The number of hooks ranges from 800 to 1,200 and hook size varies from type No 2 to 3. American type swordfish longline is a variation of the aforementioned gear with fewer hooks (350 - 700), of size No 2, much longer branch lines (15 - 50 m) and a fish attractant chemical light stick attached to each branch line one meter above the bait. Albacore longline is a much delicate version of a longline having main line of 1.0 mm Ø in cross section, shorter branch lines (3) and 1,500 to 3,000 hooks of size No 7. Frozen mackerels (*Scomber scombrus* or *Scomber japonicus*) and frozen squids (*Loligo* sp.) are the baits, which are used in the swordfish fishery, while frozen sardines (*Sardina pilchardus*) are the baits mainly used in the albacore fishery.

Observers on board and at landing sites gathered fishing and operational data, performed species identification and measurements, and recorded spatial and temporal variables. Data collected included: name of fishing boat, gear used, days of each trip and fishing effort for each fishing day (number of hooks), number and weight of fish caught per fishing day by species and discards, date and geographical coordinates of each fishing set, length and weight measurements taken to the nearest cm and tenth of kg, respectively. Two-sample hypotheses test (*t*-test) was applied to check differences between the total length means of specimens caught on board and at landing. Nonparametric Analysis of Variance (Kruskal-Wallis test) was performed to compare the total length medians of the samples by sampling area and fishing gear.

To investigate trends in relative shark abundance, nominal catch-per-unit-effort (CPUE) was used, as number of fish/1,000 hooks. Fishing time was assumed to be equal

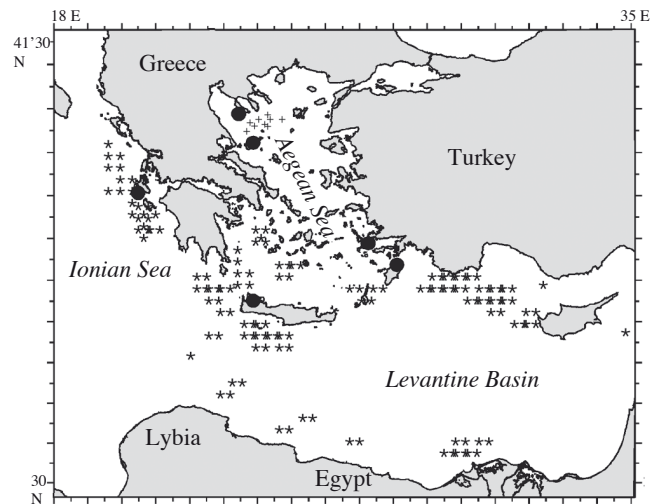


Figure 1. - Map indicating the fishing ports (black dots) and sampled fishing areas in the eastern Mediterranean Sea during the four-year period 1998-2001. (\*): Swordfish fishery area; (+) Albacore fishery area. [Carte indiquant les ports (points noirs) et les zones de pêche en Méditerranée orientale pendant la période 1998-2001. (\*): Zones de pêche de l'espadon; (+): Zones de pêche du thon albacore.]

since soaking time was almost constant, setting beginning at dusk and retrieving before sunrise.

## RESULTS

Between April 1998 and September 2001, the observers reported a total of 166 pelagic sharks as part of the swordfish and albacore longline catch in 694 fishing days of sampling (571 observations at landing and 123 on board). Eight shark species were identified, blue shark, *Prionace glauca*, being the most common shark species in all areas and gears studied (71.1% in number). Tope shark, *Galeorhinus galeus* (L., 1758), shortfin mako, *Isurus oxyrinchus* Rafinesque, 1810 and common thresher shark, *Alopias vulpinus* (Bonnaterre, 1788), were the next most abundant shark species. The rest four species were reported only once or twice and were represented by: bigeyed thresher shark, *Alopias superciliosus* (Lowe, 1839), great white shark, *Carcharodon carcharias* (L., 1758), sharpnose sevengill shark, *Heptranchias perlo* (Bonnaterre, 1788) and bigeyed sixgill shark, *Hexanchus nakamurai* (Springer & Waller, 1969) (Fig. 2).

Sharks were the second most important by-catch, following bluefin tuna, *Thunnus thynnus*, in all fishing gears sampled. In SWO-LL<sub>A</sub> their catches were higher (4.0% in number and 4.0% in kg) than in ALB-LL (2.2% in number and 0.9% in kg). Swordfish fishery catch composition by area showed higher percentages of shark catches in the Ionian Sea (5.6%), followed by the Levantine Basin (4.3%) and the Aegean Sea (3.8%). Specimens caught were larger in the

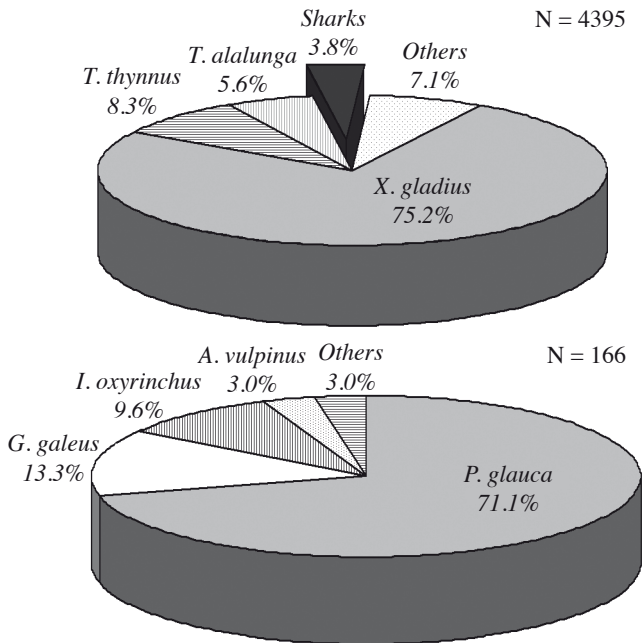


Figure 2. - Total catch composition and shark composition by species caught in the swordfish and albacore longlines during the four-year period 1998-2001 in the eastern Mediterranean Sea. [Répartition totale des captures et répartition par espèce des requins capturés dans les pêcheries palangrières d'espadon et de thon albacore en Méditerranée orientale.]

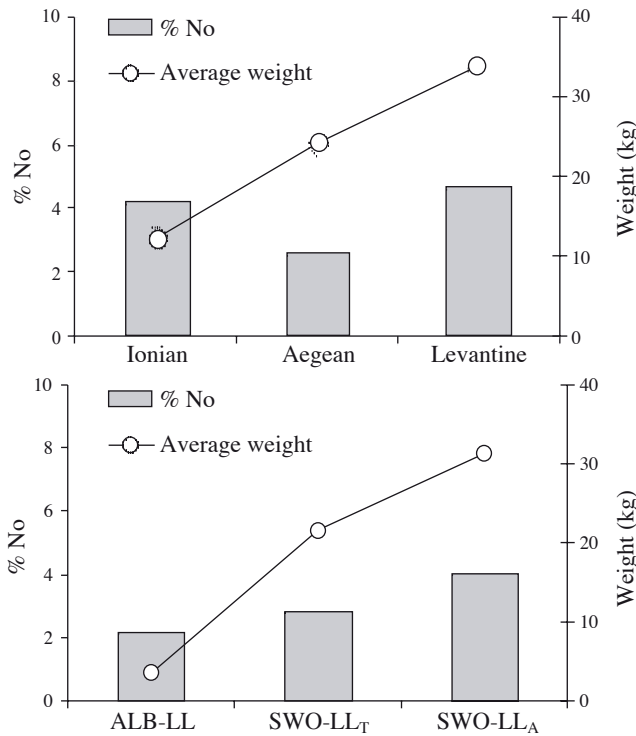


Figure 3. - Percentages of shark catches in number of fish (left Y-axis) and mean weight (right Y-axis), by area and fishing gear. [Pourcentage de requins capturés, en nombre de poissons (axe Y gauche) et en poids moyen (axe Y droit), par zone et engin de pêche.]

Table I. - Summary statistics of total length (in cm) for the eight shark species caught by swordfish and albacore longlines in the eastern Mediterranean Sea during the four-year period 1998-2001. [Statistiques résumant la taille totale pour huit espèces de requins capturées par les pêcheries palangrières d'espadon et de thon en Méditerranée orientale pendant la période 1998-2001.]

Species	N	Mean	SD	Min.	Max.
<i>Prionace glauca</i>	116	216.4	49.0	100.5	329.0
<i>Galeorhinus galeus</i>	22	143.6	21.4	126.5	190.0
<i>Isurus oxyrinchus</i>	16	164.4	43.9	101.5	270.5
<i>Alopias vulpinus</i>	7	344.0	108.8	211.0	514.5
<i>Alopias superciliosus</i>	2	253.0	151.0	146.0	360.0
<i>Carchardon carcharias</i>	1	429.0	-	429.0	429.0
<i>Heptranchias perlo</i>	1	104.0	-	104.0	104.0
<i>Hexanchus nakamurai</i>	1	106.0	-	106.0	106.0

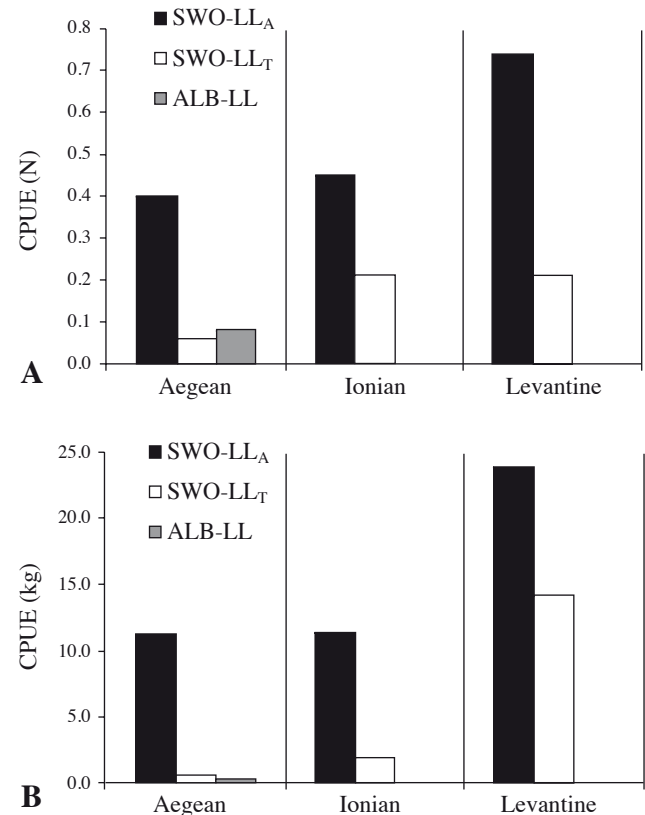


Figure 4. - Sharks CPUE (catches/1,000 hooks) in number of fish (A) and kg of fish (B), by area and fishing gear. [CPUE des requins (captures/1 000 hameçons), en nombre (A) et en kg de poissons (B), par zone et engin de pêche.]

Levantine Basin, with an average weight of 33.7 kg, and smaller in the Ionian Sea, with an average weight of 12.4 kg. Besides, the larger specimens, with an average weight of 31.3 kg, were caught by the SWO-LL<sub>A</sub> (Fig. 3).

Mean, standard deviation, minimum and maximum of total length measurements for the eight shark species are

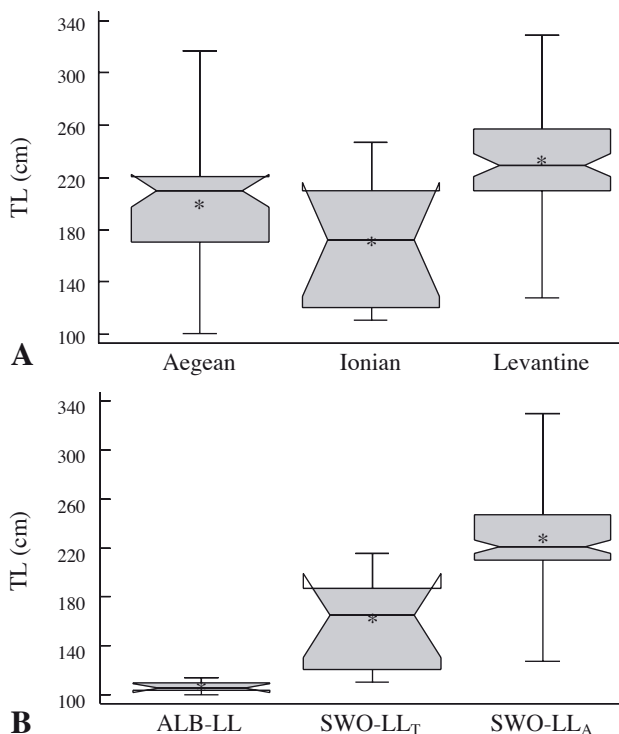


Figure 5. - Total length box plots for blue shark in the eastern Mediterranean Sea during the four-year period 1998-2001. **A:** By area; **B:** By fishing gear. (\* = mean; Horizontal line = median; Vertical lines = min. and max.; Shaded area = 50% of observations; Notch = 95% confidence interval for the median). [Longueur totale des requins bleus capturés en Méditerranée orientale pendant la période 1988-2001. **A :** Par zone ; **B :** Par engin de pêche. (\* = moyenne ; Lignes horizontales = médiane ; Lignes verticales = min. et max. ; Zone grisée = 50% des observations ; Cran = 95% de l'intervalle de confiance pour la médiane).]

presented in table I. Length distribution of blue shark, the only species with an acceptable number of data to allow a further analysis, varied significantly both by area and fishing gear (Kruskal-Wallis test;  $p < 0.05$ ). The smaller specimens were captured in the Ionian Sea and the larger ones in the Levantine Basin (Fig. 4). No statistically significant differences between the size distributions of specimen measured on board and at landing were found ( $t$ -test,  $p > 0.05$ ).

Catch per unit effort values for individual sets ranged from 0 to 6.67 sharks/1,000 hooks. In total, there were 469 out of 595 swordfish longline sets and 92 out of 99 albacore longline sets where no sharks were caught. The higher values were observed in the Levantine Basin area (Fig. 5). Seasonal variations of CPUE indicated a peak during late spring and early fall for SWO-LL<sub>A</sub> and during early summer for SWO-LL<sub>T</sub>. This pattern was observed in all of the four most important shark species prospected in the swordfish fishery (Fig. 6). Albacore fishing period covered only September and October.

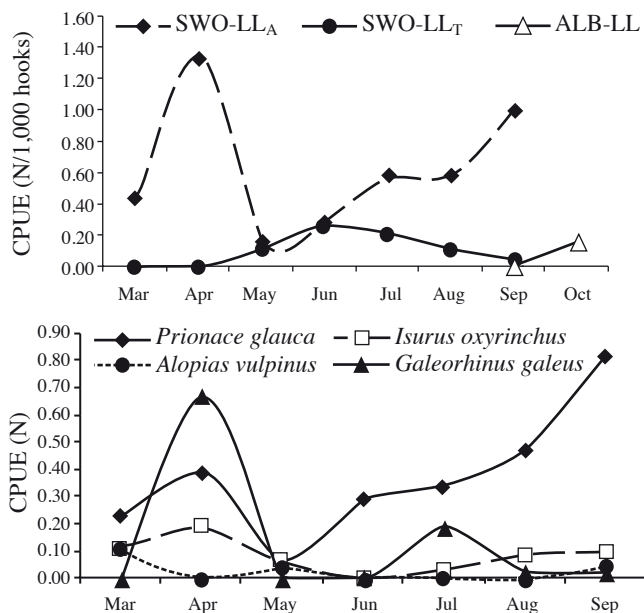


Figure 6. - Seasonal variation of shark CPUE (N/1,000 hooks) by fishing gear and of the four most important species in SWO-LLA. [Variation saisonnière des CPUE des requins (nombre/1 000 hameçons) par engin de pêche et des quatre plus importantes espèces de requin dans SWO-LLA.]

### DISCUSSION

The percentage of shark catches in the longline fishery of the eastern Mediterranean was smaller than those found by previous studies in the northern Ionian Sea (De Metrio *et al.*, 1984; Filanti *et al.*, 1986), Thyrrhenian Sea (Di Natale, 1998) and Alboran Sea (Buencuerpo *et al.*, 1998). Among the eight species recorded, bigeyed thresher shark (*Alopias superciliosus*) was reported for the first time in the Aegean Sea, while bigeyed sixgill shark (*Hexanchus nakamurai*) for the first time in the eastern Mediterranean. The latter has been reported only once in the past in the western Mediterranean waters (Ligurian Sea; Tortonese, 1986). The dominance of blue shark is consistent with results from other studies worldwide (Bigelow and Schroeder, 1948; Strasburg, 1958; De Metrio *et al.*, 1984; Filanti *et al.*, 1986; Stevens, 1990; Buencuerpo *et al.*, 1998; Nakano, 2000; Kotas *et al.*, 2000).

Size distributions of most pelagic shark species caught during this study indicated that the eastern Mediterranean Sea is inhabited both from large individuals and juveniles. Mean total length of blue shark was 222.7 cm in swordfish fishery and 108.5 cm in albacore fishery. Previous studies report mean values ranging from 92.6 to 227.0 cm, depending on area and fishing gear (Strasburg, 1958; McKinnel and Seki, 1998; Buencuerpo *et al.*, 1998; Kotas *et al.*, 2000; Henderson *et al.*, 2000; Simpfendorfer *et al.*, 2002). The differences found between the three investigated areas (Ionian, Aegean, Levantine) showing lower mean length in the Ioni-

an and larger in the Levantine Basin could be the result of segregation by size, age and/or sex (Strasburg, 1958; Nakano, 1994). Lower fishing effort in the high seas of the Levantine Basin area might be another possible reason. In fact, swordfish mean length in the area is also some of the highest in the Mediterranean (Megalofonou *et al.*, 2001). Size variation by fishing gear was an expected result as it has been documented in the past (De Metrio *et al.*, 1984; Buencuerpo *et al.*, 1998). It is obvious that larger individuals can be handled only from gears that can tolerate their weight and force and consequently different gear acts upon different sizes. On the other hand depths where fishing takes place can affect the size of the fish caught. SWO-LL<sub>A</sub> fish in much deeper waters, often below 40 m, while ALB-LL and SWO-LL<sub>T</sub> depth ranges rarely exceed 10 and 20 m respectively. Short-fin mako (*Isurus oxyrinchus*) showed an average total length of 164.4 cm. Moreno and Moron (1992) reported 165.9 cm for the eastern Atlantic and the western Mediterranean, whereas Buencuerpo *et al.* (1998) recorded 110.0 cm for the Strait of Gibraltar. In contrast, Strasburg (1958), in the Pacific Ocean, cites 205.9 cm and Pratt and Casey (1983) 195.0 cm in the North Atlantic. Tope shark (*Galeorhinus galeus*) catches consisted of adult specimens with a mean total length of 143.6 cm. Official records of the New Zealand Ministry of Fisheries, between 1983-1999, report an average total length of 120 cm (Anonymous, 2002). Maximum reported length is 195 cm from N. Pacific (Compagno, 1984), which is very close to the 190.0 cm of this study.

In our study catch rates were very low (< 0.75 sharks/1,000 hooks or < 24.0 kg/1,000 hooks). In literature, swordfish longline CPUE values ranged from 1.3-1.6 sharks/1,000 hooks in the N. Ionian Sea (De Metrio *et al.*, 1984; Filanti *et al.*, 1986), up to 24.2 sharks/1,000 hooks in the Strait of Gibraltar (Buencuerpo *et al.*, 1998). Higher values were observed for long liners in the Atlantic Ocean, which ranged from 1.0 to 43.8 sharks/1,000 hooks (Buencuerpo *et al.*, 1998; Hazin *et al.*, 1998; Nakano, 2000; Kotas *et al.*, 2000; Stone and Dixon, 2001), and in the Pacific Ocean, from 1.0 to 84.6 sharks/1000 hooks (Strasburg, 1958; Nakano, 1994; Walsh and Kleiber, 2001). The reasons for the difference in catch rates and presumably abundance, between the areas examined are difficult to elucidate because of sharks complex population structure. One hypothesis however could be that sharks in Levantine Basin are impacted less heavily by large pelagic fisheries, perhaps because of less fishing effort. The low catch rates characterizing the regional demography of sharks in the eastern Mediterranean is probably due to differential geographic distribution by size and/or sex, which is the norm for highly migratory sharks (J.A. Musick, pers. comm.). Spatial and temporal segregation of pelagic sharks has already been documented from Strasburg (1958) and Nakano (1994). Another reason could be the differentiation of the longline in some areas,

making it more robust and minimizing the possibility of sharks cutting off the line and escaping capture. Kotas *et al.* (2000) report that off northern Brazil gradually and due to increasing demand for shark fins, the final 1 meter of monofilament nylon line has been replaced by steel wire. Although this fishing gear is still registered as a swordfish longline it targets sharks as well. The use of swordfish longline had the largest numerical effect on the probability of catching shark during a fishing set. This suggests that the robustness of the gear significantly affects the catch of sharks.

The seasonal variation findings are in agreement with Buencuerpo *et al.* (1998), who also reported maximum catch rates in April and September. Certain water temperature preferences of sharks force them to shift to deeper, cooler water masses, especially in tropical and subtropical areas. In these depths they are less vulnerable to surface longlining and that reflects in lower catch rates (Strasburg, 1958; Carey and Scharold, 1990; Nakano, 1994; Bigelow *et al.*, 1999). Carey and Scharold (1990), studying blue sharks using acoustic telemetry techniques, report a change in their behavior during spring, minimizing diurnal vertical migrations and limiting their movements in the surface layer. This observation may be the reason for the seasonal peak in CPUEs observed during spring.

Regarding the status of pelagic sharks in eastern Mediterranean Sea, due to the paucity of existing data, no speculation could be made upon the time trend in catches (declining, stable or increasing). However, our results suggest that in any drifting longline gear targeting large pelagic fish many hundreds or thousands of sharks are killed in the eastern Mediterranean Sea each year.

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