Incidental catch and estimated discards of pelagic sharks from the swordfish and tuna fisheries in the Mediterranean Sea

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Abstract—Large pelagic sharks are caught incidentally in the swordfish and tuna fisheries of the Mediterranean Sea. In our study, twelve shark species were documented as bycatch over three years from 1998 to 2000. Blue shark (*Prionace glauca*) was the predominant species in all gears and areas examined. Shortfin mako (*Isurus oxyrinchus*), common thresher shark (*Alopias vulpinus*), and tope shark (*Galeorhinus galeus*) were the next most abundant shark species—found in more than half of the areas sampled. Catch composition varied both in the areas and gears investigated. Sharks represented 34.3% in weight of total catches sampled in the Alboran Sea and 0.9% in the Straits of Sicily. Higher shark catches were observed in the swordfish longline fishery, where a nominal CPUE value reached 3.8 sharks/1000 hooks in the Alboran Sea. Size distribution by fishing gear varied significantly. Albacore longline catches consisted mainly of juveniles, whereas subadult and adult specimens were more frequent in the swordfish longline and driftnet fishery. The percentage of sharks brought onboard alive was exceptionally high; only 5.1% of the specimens died. Few discards (seven blue shark) were recorded in the Greek longline fleet during onboard sampling in the Aegean Sea.

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The effect of fishing on shark stocks has become the focus of considerable international concern. The fishery-induced depletion of stocks is made worse by the slow growth, late maturity, and low fecundity of sharks, all of which make them extremely vulnerable even to modest levels of fishing. Although no pelagic shark-directed fishery exists in the Mediterranean Sea, other pelagic fisheries may be a great threat, because species with higher production rates, such as swordfish and tuna, continue to support the fishery while species with lower rebound potential are driven to stock collapse or extirpation (Musick et al., 2000). In recent years sharks, which were once considered bycatch (and discarded), have become a target species of the Spanish swordfish fleet because highly restrictive measures regulating swordfish catch have been established in the Atlantic Ocean, coupled with the fact that the international market is now more open to pelagic sharks and their derivatives (Mejuto and de la Serna, 2000).

Most pelagic sharks are migratory species. Thus, effective management proposals require reliable data that reflect migratory patterns, and multilateral international agreements are needed between all Mediterranean countries involved. During the last 40-year period, Spanish, Italian, and Greek longline and driftnet fleets have operated throughout the Mediterranean, targeting mainly swordfish or albacore and bluefin tuna. Catches began to expand slowly after 1962, increased rapidly with the advent of monofilament driftnets, and peaked in the late 1980s (Anonymous, 1999). Until recent years sharks were the most abundant incidental catch (landed, but not specifically targeted, or discarded). But they may become

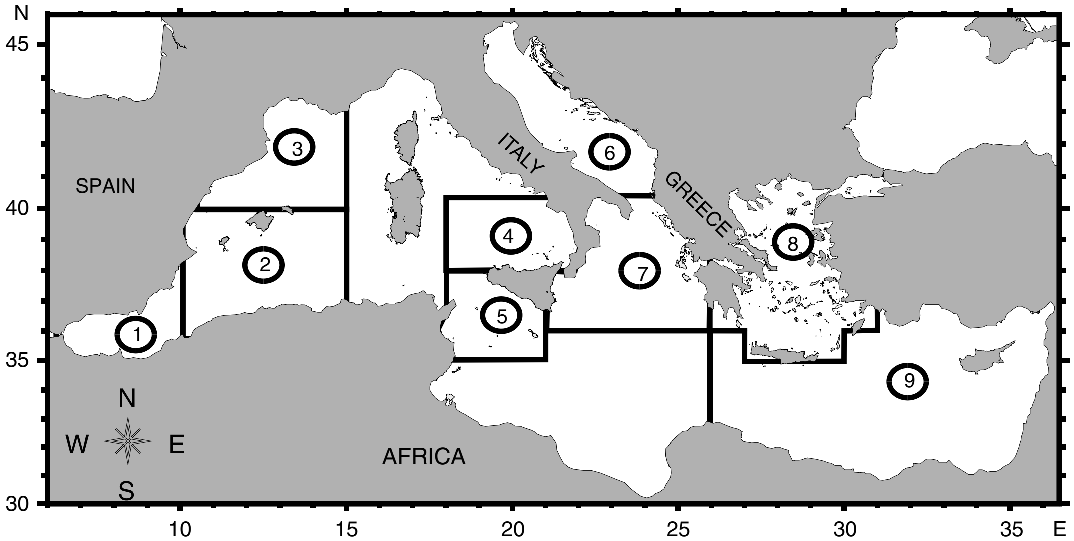

Figure 1

Map of the Mediterranean Sea, showing the nine study areas used for sampling sharks during 1998–2000. 1=Alboran Sea, 2=Balearic Islands area, 3=Catalonian Sea, 4=Tyrrhenian Sea, 5=Straits of Sicily, 6=Adriatic Sea, 7=Ionian Sea, 8=Aegean Sea, and 9=Levantine basin.

target species because their current low market value now appears to be increasing. Many of the data requirements of pelagic shark assessment are similar to those for assessing other highly migratory species: knowledge of stock structure, age and growth rates, natural mortality rates or fishery statistics. However, there is scant information about either the population biology or the catch levels of most incidental species. Primary literature on pelagic shark incidental catch in the Mediterranean Sea is rare and relates only to subareas that are not studied in a coordinated manner (De Metrio et al., 1984; Filanti et al., 1986; Buencuerpo et al., 1998; Di Natale, 1998; Mejuto et. al., 2002). ICCAT reports on pelagic shark catch show great annual variation in catch statistics and are fragmented because not all countries submit data for the entire time series. Catches of Selachii reported by FAO statistics for Spain, Italy, and Greece in the Mediterranean amount to 4209 metric tons in 2000, but include pelagic and benthic sharks, skates, rays, and chimaeras together.

Given the scarcity and heterogeneity of the available data, an international project was established (Megalofonou et al.[1]) to collect fishing and biological data with standardized methods from all commercial fisheries of the European countries that catch pelagic sharks in the Mediterranean. This article presents the results of the investigations carried out by observers at landing sites and onboard fishing vessels that target swordfish and tunas with longlines and driftnets. The main objective of this study was to analyze shark incidental catch and discards and to provide information on species composition, distribution, and abundance. The status of each shark brought on board (alive, dead, or damaged) and the disposition of sharks caught on some vessels (kept or discarded) were examined by using onboard observations to obtain essential data for effective fisheries management.

Materials and methods

Sampling areas

The Mediterranean Sea is a semi-enclosed area with pronounced oligotrophy in the surface waters due to small amounts of nutrient discharge from the land. The shallow and narrow Strait of Gibraltar connects it to the Atlantic. It consists of two nearly equal-sized basins, the eastern and the western basin, connected through the narrow and shallow Straits of Sicily. A network of sampling ports throughout the Mediterranean was established in order to cover a wide range of fishing grounds, fleets, and gears. The sampling areas, shown in Figure 1, were the following: the Alboran Sea (1), the Balearic Islands area (2), the Catalonian Sea (3), the Tyrrhenian Sea (4), the Straits of Sicily (5), the Adriatic Sea (6), the Ionian Sea (7), the Aegean Sea (8), and the Levantine basin (9). Researchers from Greece, Italy, and Spain were involved in data collection concerning incidental catch of pelagic sharks in the Mediterranean Sea.

[1] Megalofonou, P., D. Damalas, C. Yannopoulos, G. De Metrio, M. Deflorio, J. M. de la Serna, and D. Macias. 2000. Bycatches and discards of sharks in the large pelagic fisheries in the Mediterranean Sea. European Union Project 97/50 Directorate General XIV/C1, 336 p. Directorate-General for Fisheries and Maritime Affairs, European Commission, Rue Joseph II, 99, B-1049 Brussels.

Description of gear

Fleets sampled by observers targeted swordfish (*Xiphias gladius*), albacore (*Thunnus alalunga*), or bluefin tuna (*Thunnus thynnus*). Five fishing gears were studied: swordfish longline (SWO-LL), "American type" swordfish longline (SWO-LL_A), albacore longline (ALB-LL), bluefin tuna longline (BFT-LL), and driftnet (DN).

The swordfish longline consists of a nylon monofilament main line, 2 to 3 mm in diameter, hung in a sagging curve between surface floats. Branch lines with a length of 5–18 m descend from the main line, each terminating in a single baited J-hook. The number of hooks ranges from 800 to 2800 and hook size varies from no. 0 to 5. The "American type" swordfish longline, a variation of the aforementioned gear and used mainly in Greece, was introduced in the Greek fishery in the mid 1980s. It consists of fewer hooks (350–700) of size 2, much longer branch lines (15–50 m), and a fish attractant light stick (Duralumes® Lindgren-Pitman Inc., Pompano Beach, FL) attached to each branch line, 1 m above the bait. The albacore longline is a more lightly constructed longline that has 800 to 4000 J-hooks, hook sizes 6–9, a main line from 1 mm to 1.6 mm in diameter, and shorter branch lines (3–6 m). The bluefin tuna longline is the most robust longline, having 1000 to 1200 J-hooks of size 0 or 1, a main line 5.0 mm in diameter, and branch lines 45 m long. Frozen mackerels (*Scomber scombrus*) or (*Scomber japonicus*) and frozen squids (*Illex* sp.) or (*Loligo* sp.) are used as baits, as in the swordfish and bluefin tuna fishery, whereas frozen sardines—*Sardina pilchardus* or *Sardinella* sp.—are the baits mainly used in the albacore fishery. Driftnets, ranging from 2.5–20 km in length and from 24–40 m in height and having a stretched mesh size of 380 mm, were used mainly in Italy by the swordfish and tuna fishery. Since 1998, after the enforcement of the regulatory measures for the driftnets, the traditional nets were rejected and the Italian fishermen introduced a smaller driftnet, called ferrettara. This net has a length of 2.5 km, a depth from 18 to 25 m, and a mesh size of 180 mm. All gears targeting large pelagic fish, both longlines and nets, are shot (deployed) in the evening and their retrieval begins after midnight. Among the gears sampled, the swordfish longline is the main gear used in the Mediterranean Sea.

Data collection and statistical analyses

Sampling was carried out during a three-year period from 1998 to 2000. Catch and effort data were derived from records taken by observers stationed both at main fishing ports and onboard 11 commercial fishing vessels, from January 1998 to December 1999. Biological data, such as size and sex of sharks caught, were obtained from January 1998 to September 2000. Observers were present on fishing trips (702 fishing days) and at 17 landing sites, performing duties that included collecting fishing and operational data, identifying and measuring fish, as well as recording the exact location and date for each fishing set. From each fishing vessel sampled at-sea, these observers collected the following fishing and operational data series: name of fishing boat, gear used, duration of each trip in days, fishing effort per fishing day (number of hooks for longline gear, net length, and depth in meters for driftnet gear), number and weight of fish caught per fishing day by species, and number of sharks discarded. Because fishermen generally do not keep reliable logbooks to report their daily catch, sampling at landing sites was performed through interviews, as well as by direct observations and measurements. From each boat sampled at the landing site, observers, interviewing fishermen or skippers of the vessels, collected data on the duration of each trip in days, the number of fishing days, the fishing area, and the fishing effort per fishing day. The number and weight of fish landed were observed and measured directly during landing and recorded by species. Biological data for the specimens caught included total length (TL) in cm, fork length (FL) in cm, dressed weight (to the nearest 0.1 kg), and sex when possible.

To investigate trends in the abundance of sharks, we used the nominal catch per unit of effort (CPUE) expressed as the number of individuals per 1000 hooks for longlines, and per 1000 m of net for driftnets. Fishing duration was assumed to be constant because soak time was almost the same for all trips. Setting began at dusk and retrieving began after midnight. Each shark brought onboard vessels was assessed according to the following scale: 1) good—very high motility and active behavior; 2) fair—moderate motility; 3) poor—poor motility but having the ability to respond to external stimuli; 4) dead or showing no response to external stimuli.

Chi-square (χ^2) tests were performed to test variations in species composition by type of fishing gear, area sampled, and by sampling onboard or at landing sites. Catch data were classified in rows (species) and columns (gears, areas sampled, or sampling venue [fishing vessel or landing site]) to create contingency tables and were tested for significant association between rows and columns, assuming that row and column classifications are independent (null hypothesis). Nonparametric analysis of variance (Kruskall-Wallis test) was performed to compare the total length medians of the samples by fishing gear and per area. Nonparametric analysis of variance was used because our data sets did not meet the criteria needed to use the classical method of analysis of variance (ANOVA) e.g., normally distributed populations, equal variances.

Results

A total of 8733 sharks (153.6 t biomass) and 131,912 fish of other species (teleosts, rays, and skates) were documented from 5826 fishing days sampled, 5124 at landing sites and 702 onboard, during the two-year period 1998–99 (Tables 1–2). In all areas examined throughout the Mediterranean Sea, sharks represented

Table 1

Fishing sets by gear type and number of sharks caught (landed, plus discarded) throughout the Mediterranean areas studied during 1998–99 on selected vessels observed at-sea and recorded at landing sites. Area numbers: 1=Alboran Sea, 2=Balearic Islands area, 3=Catalonian Sea, 4=Tyrrhenian Sea, 5=Straits of Sicily, 6=Adriatic Sea, 7=Ionian Sea, 8=Aegean Sea, and 9=Levantine basin). Gear abbreviations: SWO-LL=swordfish longline, ABL-LL=albacore longline, BFT-LL=bluefin tuna longline, DN=driftnet, SO-LL$_A$=American-type swordfish longline. PG=*Prionace glauca*, IO=*Isurus oxyrinchus*, AV=*Alopias vulpinus*, GG=*Galeorhinus galeus*, LN=*Lamna nasus*, AS=*Alopias superciliosus*, SZ=*Sphyrna zygaena*, HG=*Hexanchus griseus*, CP=*Carcharinus plumbeus*, SB=*Squalus blainvillei*, MM=*Mustelus mustelus,* CM=*Cetorhinus maximus*.

	Number of fishing sets					Number of sharks caught											
Area	SWO-LL	ALB-LL	BFT-LL	DN	SWO-LL$_A$	PG	IO	AV	GG	LN	AS	SZ	HG	CP	SB	CM	MM
1	1391	0	0	0	0	5057	268	11	10	0	6	1	0	0	0	0	0
2	1312	48	19	0	0	85	42	17	4	0	0	0	0	0	0	0	1
3	290	41	0	0	0	97	3	2	2	0	0	0	0	0	2	0	0
4	9	0	0	0	0	5	0	0	0	0	0	0	0	0	0	1	0
5	23	7	2	0	0	3	0	1	1	0	0	0	3	2	0	1	0
6	771	6	0	0	0	2053	0	8	0	1	0	2	0	0	0	0	0
7	594	239	0	715	0	938	0	21	0	14	0	1	0	0	0	0	0
8	0	99	0	0	42	28	0	1	1	0	0	0	0	0	0	0	0
9	7	0	0	0	211	29	8	1	1	0	1	0	0	0	0	0	0
Total	4397	440	21	715	253	8295	321	62	19	15	7	4	3	2	2	2	1

Table 2

Number of sharks discarded (by fishing gear and per area) from observations onboard fishing vessels and from interviews with fishermen at landing sites throughout the Mediterranean Sea during 1998–99. Area numbers: 1=Alboran Sea, 2=Balearic Islands area, 3=Catalonian Sea, 4=Tyrrhenian Sea, 5=Straits of Sicily, 6=Adriatic Sea, 7=Ionian Sea, 8=Aegean Sea, and 9=Levantine basin). Gear abbreviations: SWO-LL=swordfish longline, ABL-LL=albacore longline, BFT-LL=bluefin tuna longline, DN=driftnet, SO-LL$_A$=American-type swordfish longline.

		Onboard sampling (693 sharks) Number of discarded sharks						At landing sampling (8040 sharks) Number of discarded sharks reported				
Area	Sets observed onboard	SWO-LL	ALB-LL	BFT-LL	DN	SWO-LL$_A$	Sets observed at landings	SWO-LL	ALB-LL	BFT-LL	DN	SWO-LL$_A$
1	70	0	—	—	—	—	1321	0	—	—	—	—
2	192	0	0	0	—	—	1187	0	—	—	—	—
3	56	0	0	—	—	—	275	0	—	—	—	—
4	9	0	—	—	—	—	0	—	—	—	—	—
5	32	0	0	0	—	—	0	—	—	—	—	—
6	75	0	0	—	—	—	702	0	—	—	—	—
7	217	0	0	—	0	—	1331	0	0	—	0	—
8	39	0	—	—	—	7	102	0	0	—	—	0
9	12	0	—	—	—	0	206	0	—	—	—	0
Total	702	0	0	0	0	7	5124	0	0	—	0	0

6.2% in number and 13.5% in biomass of the catch sampled in swordfish and tuna fisheries. Sharks were rarely discarded from vessels and the rare instances were recorded only from areas off Greece. Out of 78 shark specimens caught by the Greek longline fishing vessels only seven blue sharks, killed onboard before they were unhooked, were thrown back to the sea. No shark discarding at sea was reported by the skippers of the fishing boats, nor by the fishermen interviewed at landing sites (Table 2). Fishermen usually do not discard their shark catch because there is a market demand for sharks in the Mediterranean countries. Twelve shark species were identified—blue shark (*Prionace glauca*), being the most common in all areas and gears studied.

Table 3

Biomass (in kg) and percentage composition of species sampled on selected vessels observed at-sea and as reported at landing sites, by fishing gear in the large pelagic fisheries of the Mediterranean Sea during 1998–99. Gear abbreviations: SWO-LL=swordfish longline, $SWO\text{-}LL_A$=American-type swordfish longline, ABL-LL=albacore longline, BFT-LL=bluefin tuna longline, DN=driftnet.

	SWO-LL		$SWO\text{-}LL_A$		ALB-LL		BFT-LL		DN		Total	
Species	kg	%	kg	%	kg	%	kg	%	kg	%	kg	%
At landing sites												
Sharks	139,056	19.01	1004	1.86	399	0.37	—	—	11,099	11.25	151,558	15.29
Swordfish	551,998	75.46	42,597	78.94	32,573	30.47	—	—	49,226	49.91	676,394	68.25
Bluefin tuna	17,511	2.39	9496	17.60	4500	4.21	—	—	31,224	31.66	62,731	6.33
Albacore	527	0.07	192	0.36	65,149	60.95	—	—	7085	7.18	72,953	7.36
Other	22,457	3.07	675	1.25	4266	3.99	—	—	—[1]	—[1]	27,398	2.76
Total	731,549		53,964		106,887		—	—	98,634		991,034	
On board												
Sharks	11,793	9.64	785	8.08	267	0.26	297	2.10	258	14.45	13,400	5.33
Swordfish	82,885	67.77	7146	73.57	5259	5.07	192	1.36	1486	83.22	96,969	38.54
Bluefin tuna	2981	2.44	1617	16.65	13,474	13.00	13,459	94.99	42	2.33	31,572	12.55
Albacore	55	0.05	23	0.24	79,107	76.32	0	0.00	0	0.00	79,185	31.47
Other	24,584	20.10	142	1.46	5546	5.35	221	1.56	—[1]	—[1]	30,493	12.12
Total	122,298		9713		103,653		14,169		1786		251,619	
All												
Sharks	150,849	17.67	1789	2.81	666	0.32	297	2.10	11,357	11.31	164,958	13.27
Swordfish	634,884	74.37	49,743	78.12	37,833	17.97	192	1.36	50,712	50.50	773,364	62.23
Bluefin tuna	20,492	2.40	11,113	17.45	17,974	8.54	13,459	94.99	31,266	31.13	94,303	7.59
Albacore	582	0.07	215	0.34	144,255	68.52	0	0.00	7085	7.06	152,138	12.24
Other	47,041	5.51	817	1.28	9812	4.66	221	1.56	—[1]	—[1]	57,891	4.66
Total	853,848		63,677		210,540		14,169		100,420		1,242,654	

[1] No weight data were available for other species.

Shortfin mako (*Isurus oxyrinchus*), common thresher shark (*Alopias vulpinus*), and tope shark (*Galeorhinus galeus*) were the next most abundant shark species and were found in more than half of the areas sampled. The rest of the shark species identified were the porbeagle (*Lamna nasus*), bigeyed thresher shark (*Alopias superciliosus*), smooth hammerhead (*Sphyrna zygaena*), bluntnose sixgill shark (*Hexanchus griseus*), sandbar shark (*Carcharinus plumbeus*), longnose spurdog (*Squalus blainvillei*), smoothhound (*Mustelus mustelus*), and basking shark (*Cetorhinus maximus*).

The proportions of shark catches were significantly different among fishing gears (χ^2=15970.7, df=36, P=0.000<0.001). Total shark catches in biomass represented 17.7% on swordfish longline gear, 11.3% on driftnet gear, and only 0.3% on albacore longline gear (Table 3). Comparisons of catch composition among the fishing gears in the same area showed similar results. In the Ionian Sea, shark percentage was higher in the swordfish longline catch than in the driftnet and albacore longline catch (Table 4). Catch composition also differed significantly by area (χ^2=494558.4, df=112, P=0.000<0.001). The higher percentage of sharks, 34.3%, was found in the Alboran Sea and the lower percentages, in the Straits of Sicily and the Catalonian Sea (Table 5). Statistically highly significant differences were detected in catch composition among types of sampling (χ^2=29760.41, df=17, P=0.000<0.001). In all fishing gears and areas examined throughout the Mediterranean Sea, sharks represented 15.3% of the total catch in biomass at landings and only 5.3% onboard vessels. Among areas sampled, three areas (the Alboran Sea, Catalonin Sea, and Balearic Island area) revealed higher shark percentages at landing sites than onboard vessels (Table 5).

Relative shark abundance varied between fisheries. Higher shark catch rates were observed in swordfish fisheries both onboard vessels and at landing sites (Table 6 and 7). Overall CPUE reached 1.30 and 0.56 fish/1000 hooks in SWO-LL and $SWO\text{-}LL_A$, respectively (Table 8). Shark catch rates were higher in the Alboran Sea and the Adriatic Sea, where the average CPUEs were 3.80 fish/1000 hooks and 1 fish/1000 hooks, respectively in SWO-LL (Table 8). The driftnet fishery had a catch rate of only 0.04 fish/1000 m of nets. The comparison of catch rates (number of shark per set) among the different gear types in the same area (the Ionian Sea) revealed that the highest CPUE values were

Table 4

Biomass (in kg) and percentage composition of species by fishing gear sampled on selected vessels observed at-sea and as reported at landing sites in the Ionian Sea during 1998–99. Gear abbreviations: SWO-LL=swordfish longline, ABL-LL=albacore longline, DN=driftnet.

	SWO-LL		ALB-LL		DN		Total	
Species	kg	%	kg	%	kg	%	kg	%
Sharks	9787	13.4	568	0.5	11,357	11.3	21,711	7.5
Swordfish	43,395	59.5	35,122	30.6	50,713	50.5	129,229	44.9
Bluefin tuna	5838	8.0	5127	4.5	31,266	31.1	42,231	14.7
Albacore	0	0.0	67,594	58.9	7085	7.1	74,680	25.9
Other	13,921	19.1	6298	5.5	—[1]	—[1]	20,219	7.0
Total	72,941	100.0	114,709	100.0	100,421	100.0	288,070	100.0

[2] No available weight data were available for other species.

Table 5

Biomass (%) by species and area from data collected at landing sites and from selected longline vessels observed at-sea in the Mediterranean Sea during 1998–99. Area numbers: 1=Alboran Sea, 2=Balearic Islands area, 3=Catalonian Sea, 4=Tyrrhenian Sea, 5=Straits of Sicily, 6=Adriatic Sea, 7=Ionian Sea, 8=Aegean Sea, and 9=Levantine basin. Other = other species.

	Areas									
Species	1	2	3	4	5	6	7	8	9	Total
At landing sites										
Sharks	35.74	2.06	1.78	—	—	14.32	7.03	0.25	1.87	15.29
Swordfish	61.77	93.24	97.80	—	—	78.24	45.68	2.68	79.12	68.25
Bluefin tuna	1.83	1.89	0.28	—	—	2.62	16.12	3.39	17.42	6.33
Albacore	0.07	0.18	0.01	—	—	0.00	26.15	87.86	0.35	7.36
Other	0.59	2.62	0.13	—	—	4.82	5.02	5.82	1.24	2.76
Aboard longline vessels										
Sharks	7.82	1.14	0.78	5.63	0.89	19.57	10.69	11.18	2.89	5.33
Swordfish	81.04	38.15	12.91	42.66	31.73	44.40	39.73	81.31	60.60	38.54
Bluefin tuna	0.06	19.24	19.02	0.00	3.93	3.99	5.49	5.72	34.97	12.55
Albacore	0.00	33.91	67.06	0.00	44.44	4.34	24.53	0.28	0.17	31.47
Other	11.08	7.56	0.24	51.71	19.01	27.70	19.56	1.51	1.38	12.12
All										
Sharks	34.34	1.74	1.35	5.63	0.89	15.11	5.52	4.88	1.93	13.45
Swordfish	62.74	73.95	61.09	42.66	31.73	73.16	41.84	35.97	77.97	63.27
Bluefin tuna	1.74	7.97	8.38	0.00	3.93	2.83	5.84	4.38	18.52	5.52
Albacore	0.07	11.99	29.01	0.00	44.44	0.65	36.02	50.79	0.34	12.70
Other	1.11	4.35	0.18	51.71	19.01	8.25	10.77	3.99	1.25	5.07

found in the swordfish longline, about 1.02 fish/fishing set, followed by the driftnet and the albacore longline CPUE values (Table 9).

Seasonality in catch rates was evident in the swordfish longline fishery; shark CPUE peaked during late spring and summer, whereas swordfish CPUE peaked during fall and winter (Fig. 2). In the driftnet fishery, shark CPUE peaked during June and swordfish CPUEs were higher during June and July (Fig. 3).

Blue shark was the most abundant shark species in all areas and gears examined. It accounted for almost 95% of all sharks caught. Higher catch rates were observed in the swordfish fishery with an average value of 1.24 fish/1000 hooks in SWO-LL and 0.45 fish/1000 hooks in SWO-LL_A fishery. Analysis of catch rates by area showed that blue shark was caught more frequently in the Alboran and Adriatic Sea, reaching 3.59 fish/1000 hooks and 1.00 fish/1000 hooks, respectively (Table 8).

Table 6

Fishing sets, effort (×1000 hooks or 1000 m of net) and catch rates (number of fish/1000 hooks or number of fish/1000 m of net) of sharks and target species sampled on board in the large pelagic fisheries of the Mediterranean Sea during 1998–99. Gear abbreviations: SWO-LL=swordfish longline, $SWO\text{-}LL_A$=American-type swordfish longline, ABL-LL=albacore longline, BFT-LL=bluefin tuna longline, DN=driftnet. Abbreviations for species: PG=*Prionace glauca*, IO=*Isurus oxyrinchus*, AV=*Alopias vulpinus*, GG=*Galeorhinus galeus*. Target species for specific gears: *Xiphias gladius* for SWO-LL, $SWO\text{-}LL_A$ and DN; *Thunnus alalunga* for ALB-LL; and *Thunnus thynnus* for BFT-LL.

				Catch rate						
Fishing gear	Area	Sets	Effort	PG	IO	AV	GG	Other sharks	Total sharks	Target species
SWO-LL	Ionian	140	267.4	0.759	0.000	0.000	0.000	0.004	0.763	3.152
	Adriatic	69	166.3	1.678	0.000	0.048	0.000	0.000	1.726	3.879
	Tyrrhenian	9	18.5	0.270	0.000	0.000	0.000	0.000	0.270	8.428
	Strait of Sicily	23	46.4	0.065	0.000	0.022	0.022	0.108	0.216	14.526
	Balearic	125	373.1	0.027	0.029	0.008	0.005	0.003	0.072	8.003
	Alboran	70	174.4	0.304	0.092	0.011	0.000	0.000	0.407	5.860
	Catalonian	15	43.5	0.299	0.023	0.023	0.023	0.046	0.414	6.989
	Total	451	1089.6	0.519	0.026	0.014	0.004	0.008	0.571	6.085
$SWO\text{-}LL_A$	Aegean	39	17.4	1.264	0.000	0.057	0.057	0.000	1.379	11.609
	Levantine	12	4.8	0.417	0.208	0.000	0.000	0.000	0.625	14.167
	Total	51	22.2	1.081	0.045	0.045	0.045	0.000	1.216	12.162
ALB-LL	Adriatic	6	15.3	0.000	0.000	0.000	0.000	0.000	0.000	22.222
	Ionian	47	112.9	0.168	0.000	0.000	0.000	0.000	0.168	13.853
	Strait of Sicily	7	17.5	0.000	0.000	0.000	0.000	0.000	0.000	127.143
	Balearic	48	158.7	0.000	0.006	0.000	0.000	0.006	0.013	23.732
	Catalonian	41	142.1	0.070	0.007	0.000	0.000	0.000	0.077	29.141
	Total	149	446.5	0.065	0.004	0.000	0.000	0.000	0.069	26.957
BFT-LL	Strait of Sicily	2	2.8	0.000	0.000	0.000	0.000	0.000	0.000	5.357
	Balearic	19	20.9	0.287	0.000	0.000	0.000	0.000	0.287	3.876
	Total	21	23.7	0.253	0.000	0.000	0.000	0.000	0.253	4.051
DN	Ionian	30	300.5	0.023	0.000	0.000	0.000	0.000	0.023	0.206

Of the 3771 blue sharks measured, individuals ranged from 40 to 368 cm TL (163.3 cm mean length and 37.7 cm SD). The overall length-frequency distribution is shown in Figure 4. The size distribution by fishing gear varied significantly (Kruskall-Wallis, test statistic=350.2, P=0.000<0.05); larger specimens were caught in the $SWO\text{-}LL_A$ and DN fishery (Fig. 5). The Levantine basin had larger individuals whereas the Catalonian Sea had smaller ones (Fig. 6). Out of 564 blue sharks, 346 were determined to be males and 218 to be females. The sex ratio (males:female) favored males in almost all areas ranging from 1.29–2.50 males:1 female. The only exception was in the Alboran Sea where females were predominant (0.61 males:1 female). Relationships between TL and FL and dressed weight are given below:

$$TL = 4.1+1.176\, FL \qquad [r^2=0.99,\ n=723]$$
$$TL = 74.6\, DW^{0.307} \qquad [r^2=0.95,\ n=555].$$

The shortfin mako was reported in five out of nine areas examined and represented 3.7% of the overall shark catches. This species was caught more often in the swordfish fishery with a mean CPUE of 0.07 fish/1000 hooks in $SWO\text{-}LL_A$ and 0.05 fish/1000 hooks in SWO-LL. Shortfin makos were more abundant in the Alboran Sea and the Levantine basin (Table 8).

The total length-frequency distribution for the 257 specimens measured is shown in Figure 4. For shortfin makos collected, almost all were juvenile and ranged from 62.5 cm to 272 cm TL (mean length of 120.6 cm and 30.9 cm SD). Each fishing gear caught a statistically significant different average TL size (Kruskall-Wallis, test statistic=23.8, P=0.000006<0.05), and larger specimens were observed in the $SWO\text{-}LL_A$ fishery (Fig. 5). As with the blue shark, larger makos came from the Levantine basin and smaller ones from the Catalonian Sea (Fig. 6). Out of 56 shortfin makos, 27 were determined to be males and 29 to be females. Sex ratio was almost equal (0.9 male:1 female). The relationship between FL and TL is given below:

$$TL = 1.136\, FL - 2.5 \qquad [r^2=0.98,\ n=49].$$

Table 7

Fishing sets, effort (×1000 hooks or 1000 m of net) and catch rates (number of fish/1000 hooks or number of fish/1000 m of net) of sharks and target species sampled in the large pelagic fisheries of the Mediterranean Sea during 1998–99 as reported at landing sites. Gear abbreviations: SWO-LL=swordfish longline, SWO-LL_A=American-type swordfish longline, ABL-LL= albacore longline, DN=driftnet. Abbreviations for species: PG=*Prionace glauca*, IO=*Isurus oxyrinchus*, AV=*Alopias vulpinus*, GG=*Galeorhinus galeus*. The target species for specific gears: *Xiphias gladius* for SWO-LL, SWO-LL_A and DN; *Thunnus alalunga* for ALB-LL.

Fishing gear	Area	Sets	Effort	Catch rate PG	IO	AV	GG	Other sharks	Total sharks	Target species
SWO-LL	Ionian	454	883.5	0.457	0.000	0.001	0.000	0.002	0.461	2.521
	Levantine	7	7.0	0.000	0.000	0.000	0.143	0.000	0.143	7.714
	Adriatic	702	1895.3	0.936	0.000	0.000	0.000	0.001	0.937	3.562
	Balearic	1187	795.7	0.087	0.038	0.018	0.003	0.000	0.145	15.474
	Alboran	1321	1232.3	4.061	0.204	0.007	0.008	0.005	4.285	11.259
	Catalonian	275	478.6	0.155	0.002	0.002	0.002	0.000	0.161	5.894
	Total	3946	5292.4	1.384	0.053	0.005	0.003	0.001	1.445	7.188
SWO-LL_A	Aegean	3	1.1	0.000	0.000	0.000	0.000	0.000	0.000	5.714
	Levantine	199	90.1	0.300	0.078	0.011	0.000	0.011	0.400	15.461
	Total	202	91.2	0.296	0.077	0.011	0.000	0.011	0.395	15.348
ALB-LL	Aegean	99	151.0	0.040	0.000	0.000	0.000	0.000	0.040	5.589
	Ionian	192	414.1	0.075	0.000	0.000	0.000	0.000	0.075	21.166
	Total	291	565.1	0.065	0.000	0.000	0.000	0.000	0.065	15.868
DN	Ionian	685	8035.8	0.034	0.000	0.002	0.000	0.001	0.038	0.215

Common thresher shark, the third most abundant shark reported in eight out of nine areas studied, accounted for 0.74% of the total shark catches. Catch rates per fishing gear were higher in the SWO-LL_A fishery with a mean CPUE of 0.02 fish/1000 hooks and per area sampled in the Aegean Sea, reaching 0.05 fish/1000 hooks (Table 8).

A total of 48 juvenile and adult common thresher sharks were measured. Length-frequency distribution was discontinuous and not very revealing because of the small number of sharks sampled (Fig. 4). Specimens ranged from 75 to 514 cm TL (mean value of 316.8 cm and SD 86.4 cm). No statistically significant differences were observed (Kruskall-Wallis, test statistic=0.638, P=0.73>0.05) in average size of specimens by fishing gear (Fig. 5). Larger specimens were reported from the Levantine basin area and a smaller one was reported from the Balearic Sea (Fig. 6). Out of 27 common thresher shark sexed, 15 were males and 12 females. Sex ratio was 1.25 male:1 female. The TL-FL and TL-dressed weight relationships are given below:

$$TL = 20.2 + 1.707\,FL \qquad [r^2=0.95,\ n=24]$$
$$TL = 69.7\,DW^{0.351} \qquad [r^2=0.99,\ n=18].$$

The remaining nine shark species observed accounted for only 0.87% of the total shark catches. In total, 26 tope sharks were measured (ranging from 35 to 190 cm), 15 porbeagles (ranging from 87 to 277 cm), 7 bigeyed thresher sharks (ranging from 146 to 353 cm) and 4 smooth hammerheads (ranging from 277 to 300 cm TL). Only three bluntnose sixgill sharks (mean weight of 10.7 kg), two sandbar sharks (mean weight of 17 kg), two longnose spurdogs (mean weight of 1.7 kg), two basking sharks, and one smoothhound were reported, but no length measurements were available for these species.

A total of 571 specimens were examined for life condition on capture. The majority were very active following capture and their physical condition was especially good. Only 5.1% of the specimens brought onboard were dead (Table 10).

Discussion

Our results show that most of the sharks caught by the swordfish and tuna fisheries in the Mediterranean Sea are typically pelagic or coastal-pelagic species of widespread distribution in temperate and tropical waters throughout the world. However, some sporadic catches of poorly known, deepwater species of the families Hexanchidae and Alopiidae were also observed. The most plausible reason for these catches is that the deepwater species ascend close to the surface at night where they may be taken by longlines targeting swordfish (Castro et al., 1999).

Table 8

Fishing sets, effort (×1000 hooks or 1000 m of net), and catch rates (number of fish/1000 hooks or number of fish/1000 m of net) of sharks and target species sampled in the large pelagic fisheries of the Mediterranean Sea during 1998–99. Sampling conducted both at sea and at landing sites. PG=*Prionace glauca*, IO=*Isurus oxyrinchus*, AV=*Alopias vulpinus*, GG=*Galeorhinus galeus*. The target species for specific gears: *Xiphias gladius* for SWO-LL, $SWO\text{-}LL_A$ and DN; *Thunnus alalunga* for ALB-LL; and *Thunnus thynnus* for BFT-LL.

Fishing gear	Area	Sets	Effort	Catch rate						
				PG	IO	AV	GG	Other sharks	Total sharks	Target species
SWO-LL	Ionian	594	1151.0	0.53	0.00	0.001	0.00	0.003	0.53	2.67
	Levantine	7	7.0	0.00	0.00	0.00	0.14	0.00	0.14	7.71
	Adriatic	771	2061.6	1.00	0.00	0.004	0.00	0.00	1.00	3.59
	Tyrrhenian	9	18.5	0.27	0.00	0.00	0.00	0.00	0.27	8.43
	Strait of Sicily	23	46.4	0.06	0.00	0.02	0.02	0.11	0.22	14.53
	Balearic	1312	1168.8	0.07	0.04	0.01	0.003	0.001	0.12	13.09
	Alboran	1391	1406.7	3.59	0.19	0.008	0.007	0.004	3.80	10.59
	Catalonian	290	522.1	0.17	0.004	0.004	0.004	0.004	0.18	5.99
	Total	4397	6382.0	1.24	0.05	0.006	0.003	0.002	1.30	7.00
$SWO\text{-}LL_A$	Aegean	42	18.5	1.19	0.00	0.05	0.05	0.00	1.30	11.27
	Levantine	211	94.9	0.31	0.08	0.01	0.00	0.01	0.41	15.40
	Total	253	113.4	0.45	0.07	0.02	0.01	0.01	0.56	14.72
ALB-LL	Aegean	99	151.0	0.04	0.00	0.00	0.00	0.00	0.04	5.59
	Adriatic	6	15.3	0.00	0.00	0.00	0.00	0.00	0.00	22.22
	Ionian	239	527.0	0.09	0.00	0.00	0.00	0.00	0.09	19.60
	Strait of Sicily	7	17.5	0.00	0.00	0.00	0.00	0.00	0.00	127.14
	Balearic	48	158.7	0.00	0.006	0.00	0.00	0.006	0.013	23.73
	Catalonian	41	142.1	0.07	0.007	0.00	0.00	0.00	0.08	29.14
	Total	440	1011.6	0.07	0.002	0.00	0.00	0.00	0.07	20.76
BFT-LL	Strait of Sicily	2	2.8	0.00	0.00	0.00	0.00	0.00	0.00	5.36
	Balearic	19	20.9	0.29	0.00	0.00	0.00	0.00	0.29	3.88
	Total	21	23.7	0.25	0.00	0.00	0.00	0.00	0.25	4.05
DN	Ionian	715	8336.3	0.03	0.00	0.002	0.00	0.001	0.04	0.21

Table 9

Fishing sets and catch rates (number of fish/fishing set) of sharks and target species in the three fishing gears studied in the Ionian Sea during 1998–99. PG=*Prionace glauca*, IO=*Isurus oxyrinchus*, AV=*Alopias vulpinus*, GG=*Galeorhinus galeus*. The target species for specific gears: *Xiphias gladius* for SWO-LL and DN; *Thunnus alalunga* for ALB-LL.

Fishing gear	Sets	Catch rate						
		PG	IO	AV	GG	Other sharks	Total sharks	Target species
SWO-LL	594	1.02	0.00	0.00	0.00	0.01	1.03	5.17
ALB-LL	239	0.21	0.00	0.00	0.00	0.00	0.21	43.22
DN	715	0.39	0.00	0.03	0.00	0.02	0.44	2.50

Onboard observations and interviews with fishermen at landing sites revealed that shark discarding is not a common practice in the large pelagic fisheries in the Mediterranean Sea. Very few shark discards were recorded and only from Greek vessels (seven blue sharks out of 78 total). The fishermen usually retain their incidental catches because there is a market demand for sharks in Europe. However, wholesale shark flesh prices are quite variable, ranging from 2 to 8 euros. Moreover, the jaws and tails of some shark species are often sold

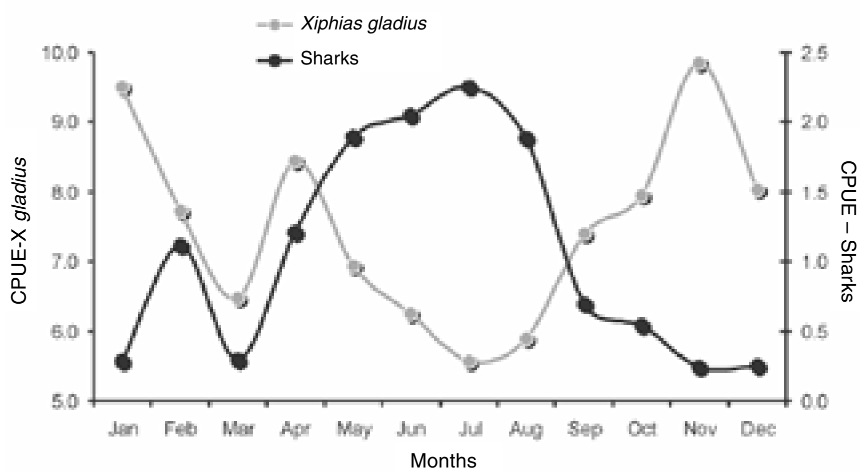

Figure 2

Monthly variation in sharks and swordfish longline CPUE (catch in numbers/1000 hooks) in the swordfish longline fishery of the Mediterranean Sea during 1998–99.

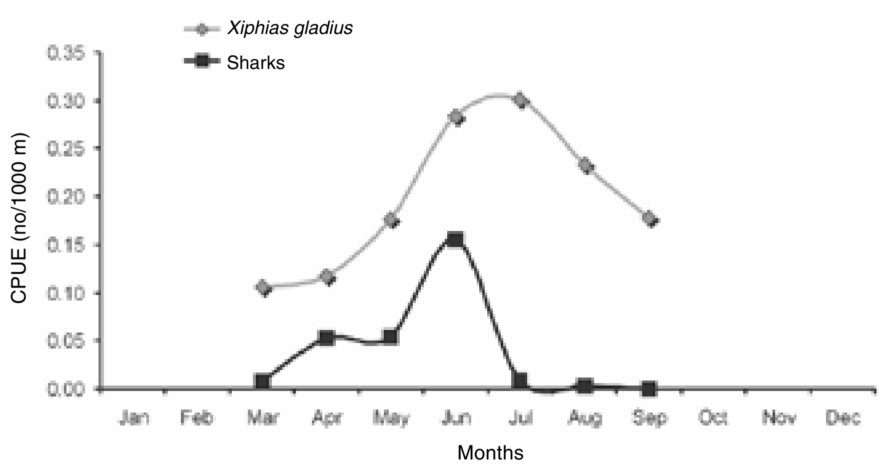

Figure 3

Monthly variation in sharks and swordfish CPUE (catch in numbers/1000 m net) in the driftnet fishery of the Mediterranean Sea during 1998–99.

in local markets. The very low discard rate of shark—about 1% of the sharks caught during onboard sampling was discarded—confirmed that sharks contribute to fishermen's income and may become target species with future increases in their market value. That discarding was observed only in the Greek swordfish fleets is probably due to the low market prices of shark meat compared to the high price of swordfish in this country. Sometimes during long trips fishermen are reluctant to retain them onboard and loose cool storage space for more valuable species such as swordfish or tuna.

The analysis of catch composition by gear and areas indicated that the various gears used in the swordfish and tuna fisheries affect the shark populations differently and that the proportion of shark catches is related both to the type of fishing gear and the sampling area. This finding is consistent with previous findings for the Mediterranean Sea where incidental shark catch in the swordfish fisheries varied from insignificant to dominant, depending on the area studied (De Metrio et al., 1984; Di Natale, 1998; Filanti et al., 1986; Buencuerpo et al., 1998; Mejuto et. al., 2002). The highest shark incidental catches were found in the Alboran Sea and were probably related to their location (Alboran Sea), adjacent to the Atlantic Ocean. Shark bycatch in the Atlantic swordfish fishery is one

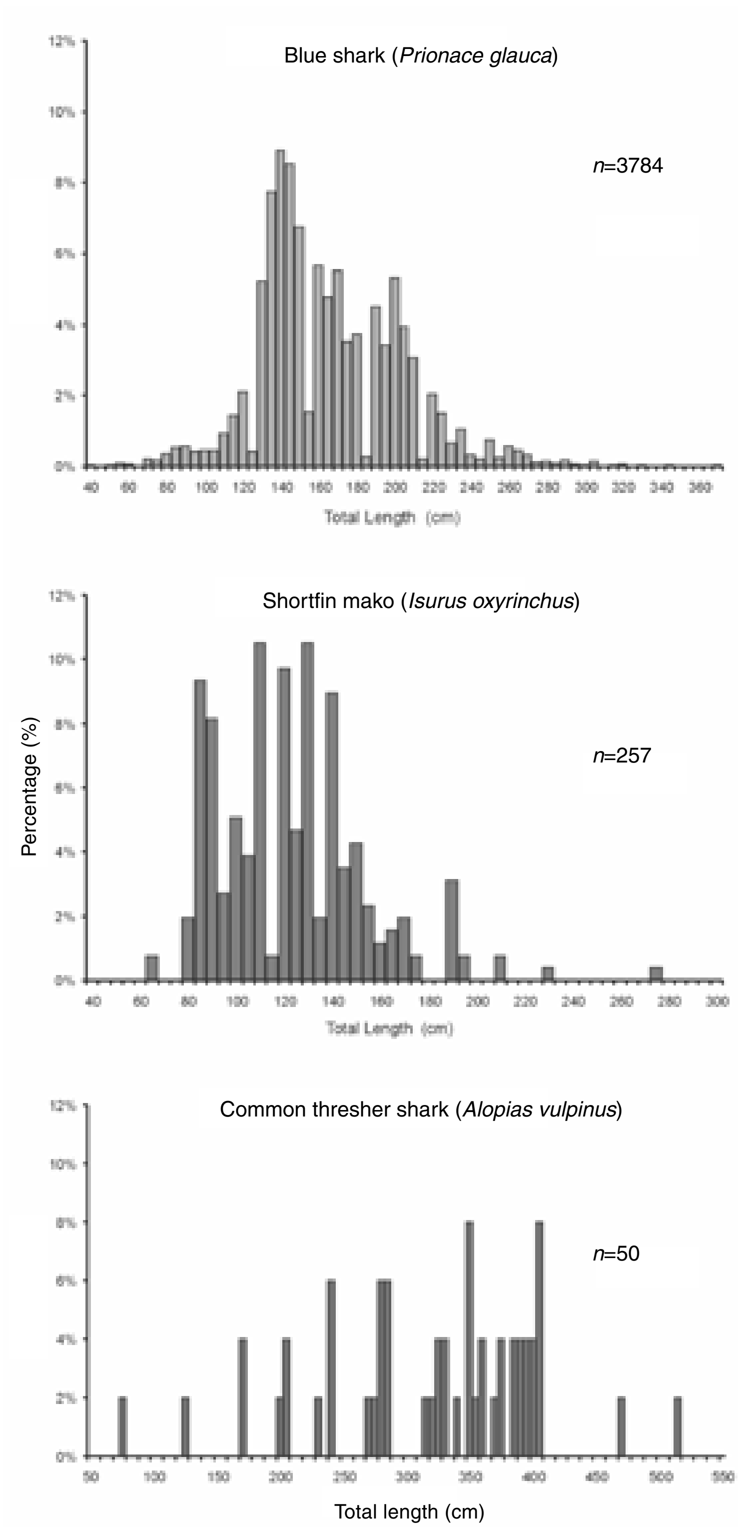

Figure 4

Length-frequency distribution (in percentage by 5-cm size classes) for *Prionace glauca*, *Isurus oxyrinchus,* and *Alopias vulpinus* sampled in the Mediterranean Sea during 1998–2000.

of the highest in the world, rarely dropping below 30% of the total catch in numbers of fish (Amorim et al., 1998; Buencuerpo et al., 1998; Hazin et al., 1998; Marin et al., 1998). The higher incidence of sharks in the Alboran Sea could also be due to the higher trophic potential of the western Mediterranean compared to the eastern part. The discrepancies in observed at-sea and at-landing data, especially in the western Mediterranean Sea catch composition, could be mainly due to the discarding of "other species." In addition, the discarding of undersize target species, such as swordfish and tunas, could be another reason for the discrepancies observed. It is reasonable that observers at landing sites were not able to record exactly the entire nonshark discards at sea from the information that fishermen provided; thus shark landings do not always reflect actual percentage of catch composition caught at sea.

The shark catch rates obtained in our study were lower than those reported in previous studies for various areas of the Mediterranean Sea (Table 11) probably because of the fishing pressure throughout the years.

A comparison of the shark catch rates in the Mediterranean and Atlantic indicated that the catch rates are generally lower throughout the Mediterranean (Table 11). Possible reasons could be either the lower productivity of the Mediterranean Sea, or, as alluded to above, lower availability of sharks in the Mediterranean due to regional depletion from historical fishing, or both. The configuration and effectiveness of fishing gears used could be another reason for the higher CPUE in the Atlantic Ocean. Hazin et al. (1998) and Kotas et al.[2] reported an increase in use of wire snoods in Atlantic swordfish fisheries to retain more sharks for the growing market for shark fins.

Monthly analysis of catches indicated that maximum catch rates occur during late spring and summer (May–August) in the swordfish longline (SWO-LL) fishery, and in June in the driftnet fishery. Monthly variations in catch rates were found also by Buencuerpo et al. (1998), who reported peaks of shark catch in April and Septem-

[2] Kotas, J. E., S. dos Santos, V. G. de Azevedo, J. H. de Lima, J. D. Neto, and C. F. Lin. 2000. Observations on shark by-catch in the monofilament longline fishery off southern Brazil and the National ban on finning, 8 p. IBAMA–REVIZEE research. [Copyright: www.wildaid.org.]

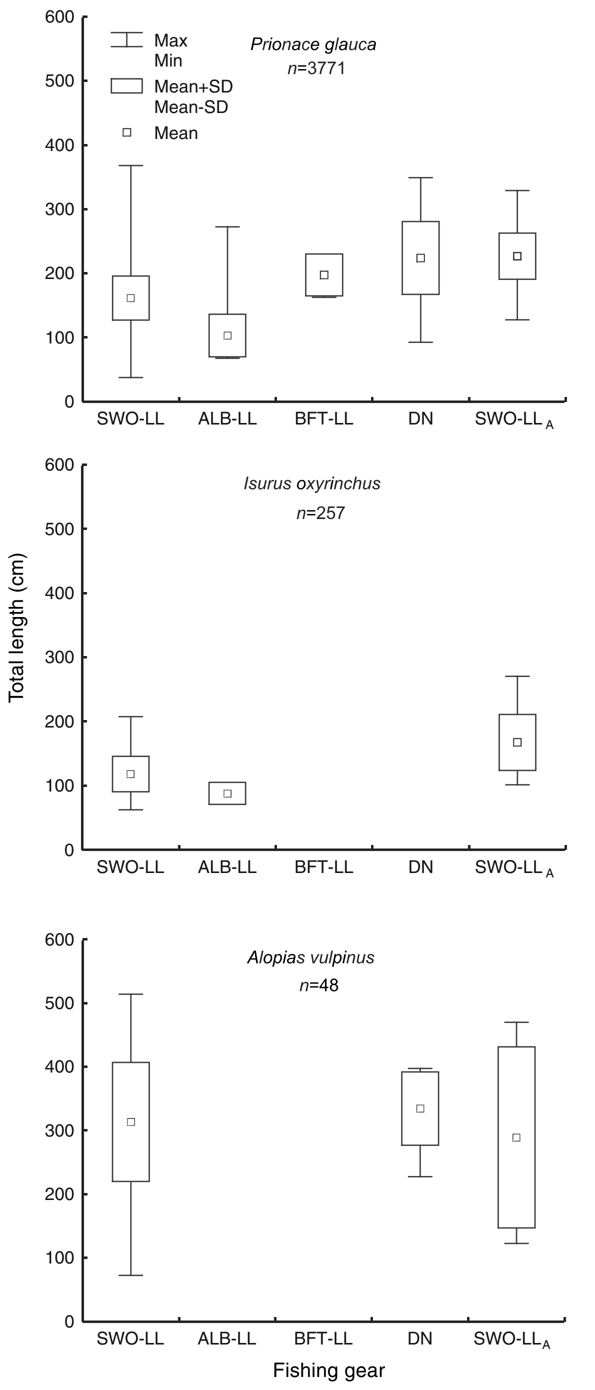

Figure 5

Size-range variation for *Prionace glauca*, *Isurus oxyrinchus,* and *Alopias vulpinus* by fishing gear in the Mediterranean Sea during 1998–2000. See Table 1 for definitions of abbreviations for fishing gear along *x* axis.

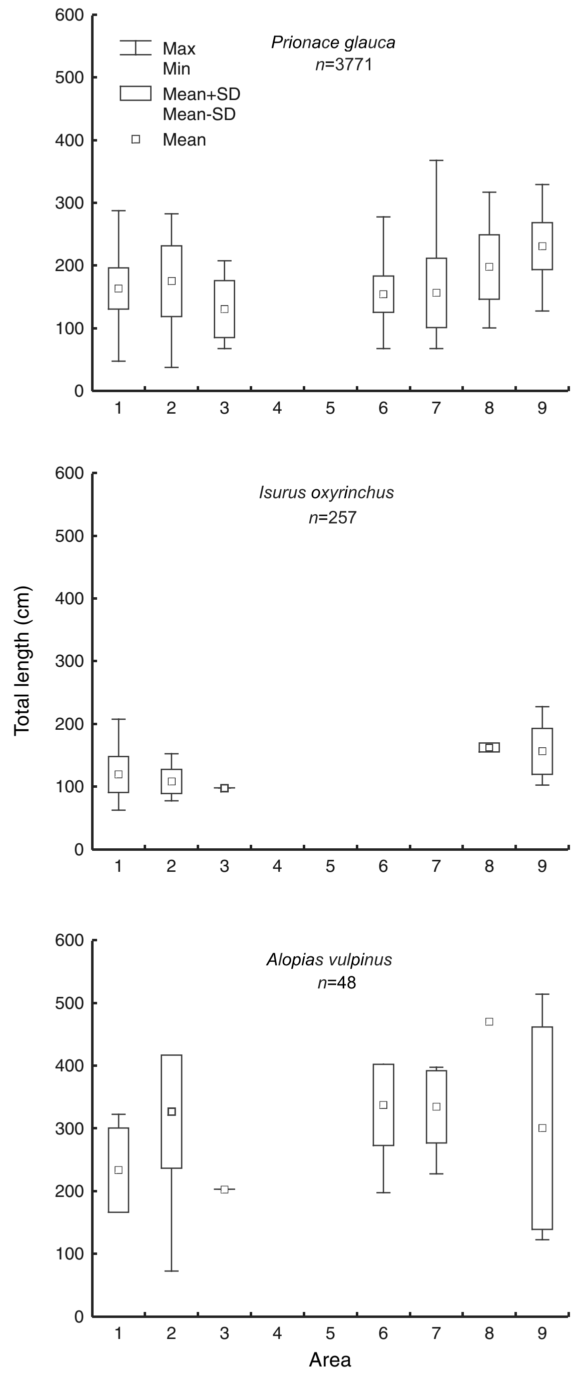

Figure 6

Size-range variation for *Prionace glauca*, *Isurus oxyrinchus,* and *Alopias vulpinus* by area sampled in the Mediterranean Sea during 1998–2000. See Table 1 for definitions of area numbers along the *x* axis.

ber in the eastern N. Atlantic and Straits of Gibraltar. Probably, certain water temperature preferences of sharks during their biological cycle force them to shift to shallower and warmer water masses, especially in summer. At these depths sharks are more vulnerable to surface gears and that is reflected in higher catches. Higher catch rates in late spring and summer could be also attributed to juvenile recruitment (Strasburg,

Table 10

Life-status condition of 571 sharks at time of capture, by species, and per fishing gear, observed onboard commercial fishing vessels in the Mediterranean Sea during 1998–2000. Gear abbreviations: SWO-LL=swordfish longline, $SWO\text{-}LL_A$=American-type swordfish longline, ABL-LL=albacore longline, DN=driftnet, BFT-LL=bluefin tuna longline.

	Good		Fair		Poor		Dead	
	Number	%	Number	%	Number	%	Number	%
Species								
P. glauca	364	71.0	69	13.5	57	11.1	23	4.5
I. oxyrinchus	7	22.6	10	32.3	9	29.0	5	16.1
A. vulpinus	3	18.8	4	25.0	8	50.0	1	6.3
G. galeus	4	80.0	1	20.0	0	0.0	0	0.0
A. superciliosus	1	100.0	0	0.0	0	0.0	0	0.0
C. plumbeus	0	0.0	2	100.0	0	0.0	0	0.0
H. griseus	3	100.0	0	0.0	0	0.0	0	0.0
Fishing gear								
SWO-LL	334	66.8	76	15.2	64	12.8	26	5.2
$SWO\text{-}LL_A$	34	97.1	0	0.0	0	0.0	1	2.9
ALB-LL	12	46.2	6	23.1	6	23.1	2	7.7
DN	2	40.0	2	40.0	1	20.0	0	0.0
BFT-LL	0	0.0	2	40.0	3	60.0	0	0.0
Total	382	66.9	86	15.1	74	13.0	29	5.1

1958; Carey and Scharold, 1990; Nakano, 1994; Bigelow et al., 1999).

The abundance and widespread distribution of blue sharks throughout the Mediterranean that we determined supports previous findings. However, our observed catch rates were lower than those reported earlier for the same areas (De Metrio et al., 1984; Filanti et al., 1986; Buencuerpo et al., 1998; Di Natale, 1998; Relini-Orsi et al., 1999; De Zio et al., 2000). Variation in sex ratio and size distribution between different areas studied indicated sexual or size segregation, or both. Spatial and temporal segregation of pelagic sharks by sex and size was well documented by Strasburg (1958) and Nakano (1994) in the Pacific Ocean. Further analysis regarding distribution by latitude-longitude, time of year, and size classes of specimens is needed to establish a possible blue shark migratory pattern in the Mediterranean Sea. Pratt's estimates on the sexual maturity of blue shark (215 cm TL for males, 257 cm TL for females) from the North Atlantic Ocean (Pratt, 1979) indicate that in all areas studied in the Mediterranean Sea, albacore and swordfish longline fisheries generally capture immature to subadult specimens and driftnets and American type swordfish longlines capture adults. Of all blue sharks captured in the large pelagic fisheries of the Mediterranean during our study, 91.1% were under 215 cm TL and 96.3% under 257 cm TL. This observation, which indicates that the majority of Mediterranean blue sharks caught have not reached maturity, is of concern and reinforces the need for global assessments of this species. In the Atlantic and Pacific Ocean results based on a considerable time series of data show a decrease in abundance (Cramer, 1996) and in average size (Holts et al., 1998) of blue sharks. Because blue sharks are an incidental catch in the large pelagic and highly migratory species fisheries in the Mediterranean, standardizing catch rates is very difficult. Average size may be a more sensitive indicator of shark stock status than catch rates when there is a long enough time-series of data.

We found a much lower incidental catch of shortfin mako than other authors have reported in the Mediterranean (Dai, 1997; Buencuerpo et al., 1998). This species seems more abundant in the Atlantic Ocean where in some areas it represents more than 10% of total catches (Buencuerpo et al., 1998; Stone et al., 2001). The almost equal sex ratio reflects the findings of Buencuerpo et al., (1998) and Moreno et al., (1992). As with blue sharks, larger makos were observed in the Levantine basin although in small numbers. Because males mature at 195 cm TL (Compagno, 1984) and females between 273 and 298 cm (Mollet et al., 2000), 98.4% of shortfin makos in our study were smaller than the size of first maturity. The absence of a consistent time series of abundance data did not allow us to estimate the trend in the status of the shortfin mako population in the Mediterranean Sea. Cramer (1996) outlined a steady decline in catch indices for this species from 11.86 fish/1000 hooks in 1985, to 3.52 in 1996 for the U.S. commercial Atlantic longline fishery in the Caribbean and the Gulf of Mexico. The Azorean fleet mako landings decreased by almost 50% in numbers from 1987 to 1994 (Castro et al., 1999). Together with the low catch rates in the Mediterranean Sea, short-

Table 11

Comparison of shark catch rates (CPUE in number of fish/1000 hooks) in longline fisheries during investigations in the Mediterranean Sea and the Atlantic Ocean. SWO-LL= swordfish longline; Tuna-LL=tuna longline gear.

Author	Area	Period	Gear	CPUE
De Metrio et al. (1984) [1]	Ionian Sea	1984	SWO-LL	0.9–2.2
Filanti et al.(1986)	Ionian Sea	1978–85	SWO-LL	1.5–3.0
De Zio et al. (2000)	Adriatic Sea	1984–98	SWO-LL	2.4
Di Natale (1998)	Tyrrhenian Sea, Strait of Sicily	1991–92	SWO-LL	0.4
Buencuerpo et al. (1998)	Gibraltar Strait	1991–92	SWO-LL	24.2
Present study	Ionian Sea	1998–99	SWO-LL	0.5
Present study	Adriatic Sea	1998–99	SWO-LL	1.0
Present study	Strait of Sicily	1998–99	SWO-LL	0.2
Present study	Alboran Sea	1998–99	SWO-LL	3.8
Buencuerpo et al. (1998)	E. Atlantic	1991–92	SWO-LL	9.9–37.8
Stone and Dixon (2001)	NW Atlantic	1999	SWO-LL	43.8
Hazin et al. (1998)	W. Atlantic	1983–97	Tuna-LL	16.8

[1] Blue shark catch rates only.

fin makos may be one of the most over-fished pelagic sharks in the Mediterranean Sea.

Our low catch rates for common thresher shark in the Mediterranean were almost identical with the findings of Buencuerpo et al. (1998) for the Gibraltar Strait region. However, the abundance of this species supports directed fisheries in some areas. Such a case occurred off California waters during 1977–85, when thresher shark CPUE in the driftnet fishery ranged from 0.13 to 1.92 fish/fishing set (Holts et al., 1998). In our study, one third of the specimens caught came from the Ionian driftnet fishery but the largest individual was captured in the Levantine basin (514 cm TL) with the swordfish longline. Pacific females mature at 315 cm TL (Strasburg, 1958) and males mature at about 333 cm TL (Cailliet and Bedford, 1983), and we calculated that 40% of the female common thresher sharks caught were below 315 cm and 50% of the males were below 333 cm. Although the above data indicate that most were caught as immature sharks, there are no data on the first maturity of common thresher sharks in the Mediterranean Sea. There is doubt, however, that females mature at a smaller size than males in the same region and we therefore deduced that fishing pressure was very intense on juvenile and subadult groups.

The low capture numbers for other shark species could be due either to the scarcity of these species in the Mediterranean Sea or to the "fished-down" condition of shark populations, or both could be causes. Another reason could be the low capture efficiency of the gears used.

The high proportion of sharks that were alive on capture agrees with Kotas et al.[2], who reported that 97% of blue sharks and 78% of shortfin makos were alive when landed on deck. These high survival rates are encouraging and could become the basis for conservation measures in the future, such as releasing immature fish or enforcing catch quotas.

Our study provides a reference point for the present status of pelagic sharks in the Mediterranean Sea, the effect of fisheries on them, and a baseline for future monitoring. Fishing for swordfish and tunas affects much of the pelagic ecosystem by taking predators of swordfish and tunas (large pelagic sharks), their prey (small tunas), and their competitors, such as other elasmobranchs, billfishes, and tunas. Up to now, there has been little documentation and understanding of fishing effects on the wider ecosystem. To strengthen management for large pelagic fishes such as sharks, a multispecies assessment with an ecosystem approach should be adopted. To achieve this goal, long-term monitoring programs should be established and exploitation strategies should be linked to conservation plans for shark species in the Mediterranean Sea.

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