SHARKS AND RAYS

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INTRODUCTION

Sharks and rays belong to the taxonomic class Chondrichthyes, or cartilaginous fishes, as their internal skeleton is formed from flexible cartilage. The chondrichthyan fishes are divided in two main groups: the subclass Elasmobranchii, which is the larger and includes sharks and rays and the subclass Holocephali, which includes the chimaeras and many extinct species (fossil records). There are over 500 shark and 600 ray living species all over the world. Sharks and their relatives were much more abundant and diverse in the fossil record, which include over 3 000 fossil species. Some fossil species that lived 150 million years ago are almost identical to some modern sharks, rays and chimaeras (COMPAGNO *et. al.,* 1984).

During the last decades, primarily in response to the rapidly increasing demand for shark fins, meat and cartilage, the commercial exploitation of sharks has been rapidly increasing all over the world, making information about their life history essential for understanding and managing their populations. Today many shark species are directly targeted in some commercial and recreational fisheries and are caught incidentally as by-catch in many other fisheries. Mortality of incidentally caught sharks is believed to be significant, especially from trawl nets, gill nets, purse seines and long lines, and may exceed mortality from directed fisheries. STEVENS *et al.,* (2000) have noted that some 50% of the estimated global catch of Chondrichthyans is taken as by-catch, does not appear in official fishery statistics and is almost totally unmanaged. Shark fisheries are inadequately controlled, due in part to a lack of understanding of the limitations of traditional teleost fisheries' assessment models when applied to elasmobranchs. The major difficulties faced by researchers and managers attempting to evaluate and manage shark and ray populations are the lack of available quality data, management tools, and political will. Elasmobranch biology is generally poorly understood and little fishery – independent or taxonomic research is under way (CAMHI *et al.,* 1998).

ELASMOBRANCHII IN THE MEDITERRANEAN

Seventy nine elasmobranchii species, belonging to seventeen families exist in the Mediterranean Sea. From them 70 species are native, i.e. known to live for a very long time in the Mediterranean, but also exist in other oceans; 4 are endemic, (i.e. species living only in the Mediterranean) and 4 are introduced recently in the Mediterranean through the Gibraltar Straits or the Suez Canal. The endemic species are: *Leucoraja melitensis, Dasyatis tortonesei, Raja polystigma* and *Raja rondeleti*. The introduced species in the Mediterranean are: *Himantura uarnak* through the Suez Canal and *Carcharhinus falciformis, Carcharhinus altimus* and *Galeocerdo cuvier* through the Gibraltar Straits (GOLANI *et al.,* 2002).

Concerning their habitat, 15 species are living in deep waters, characterized as bathydemersal, 7 are benthopelagic species, 29 demersal, 6 pelagic and 21 reef-associated. The average trophic level is around 4, classifying them on a high level in the food web. Species of the Carcharirhinidae, Alopiidae, Lamnidae, Odontaspididae and Sphyrnidae families appear on a higher trophic level (www.fishbase.org). Their maximum lengths range from 160 to 980 cm. The smaller animals belong to the families Scyliorhinidae and Squalidae and the bigger to Cetorhinidae, Alopiidae, Carcharinidae and Lamnidae.

Several shark stocks, especially the pelagic, are shared stocks and are fished by different countries bordering the Mediterranean. Three elasmobranch species occurring in the Mediterranean are the most endangered: the basking shark (*Cetorhinus maximus*), the giant devil ray (*Mobula mobular*) and the great white shark (*Carcharodon carcharias*), and have been included under international conventions (Specially Protected Areas and Biological Diversity in the Mediterranean, Convention on International Trade in Endangered Species, a.o.). A monitoring programme for these species (Mediterranean Large Elasmobranchs Monitoring) has been recently created under the auspices of General Fisheries Commission for the Mediterranean (GFCM).

RESEARCH ON ELASMOBRANCH SPECIES IN HELLAS

In Hellas there is not any specific fishery targeting the elasmobranch species but they are caught as side (by-catch) or incidental catch in various fisheries. Demersal shark and ray species are caught by various trawl-net, gill net and benthic long line fisheries, while pelagic species are caught in the drifting surface long line fisheries targeting swordfish and tunas.

According to the official fisheries' statistics, the contribution of elasmobranchs to the total commercial landings is low, ranging from 1.1 to 1.4% and the annual elasmobranch landings in the last decade do not exceed the amount of 1 700 MT. However, data available in the national administrations are generally quite incomplete and in most cases elasmobranch catches are not reported on a species basis but by broader groups, which include several species. A large part of shark by-catches, especially from the small-scale fishery, is also discarded at sea and in most cases this is poorly monitored.

The main objective of the present work is to provide information on the current state of the research and the main findings concerning the biology, distribution and fishery of the most common demersal and pelagic elasmobranch species in Hellenic waters.

DEMERSAL SPECIES

A scientific bottom-trawl survey is conducted annually in the Hellenic Seas since 1994 aiming to monitor biological and population trends for a series of demersal species. The survey is realized in the frame of an international bottom trawl survey (MEDITS) covering the northern part of the Mediterranean basin and it includes sampling in 180 pre-defined stations distributed all over the Hellenic Seas. Sampling follows a common standardized protocol (BERTRAND *et al.,* 2000). Among the monitored species, are included the elasmobranchs *Scyliorhinus canicula, Galeus melastomus, Raja clavata, Raja asterias, Mustelus mustelus, Centrophorus granulosus, Squalus acanthias*. Based on the estimated abundance indices, the distribution patterns of the most common species are illustrated in figures 1 to 4. Apart from the monitored species, data on the occurrence of other demersal elasmobranch species are also recorded. These include information on the bathydemersal species *Etmopterus spinax, Heptranchias perlo, Dalatias licha, Oxynotus centrina*, *Chimaera monstrosa*, and several species of the Triakidae, Dasyatidae, Rajidae and Squatinidae families.

Based on the MEDITS data for the 1994-2000 period biomass trends in the south Aegean Sea, were examined for a list of 14 demersal species, including the elasmobranchs *Squalus acanthias* and *Scyl-*

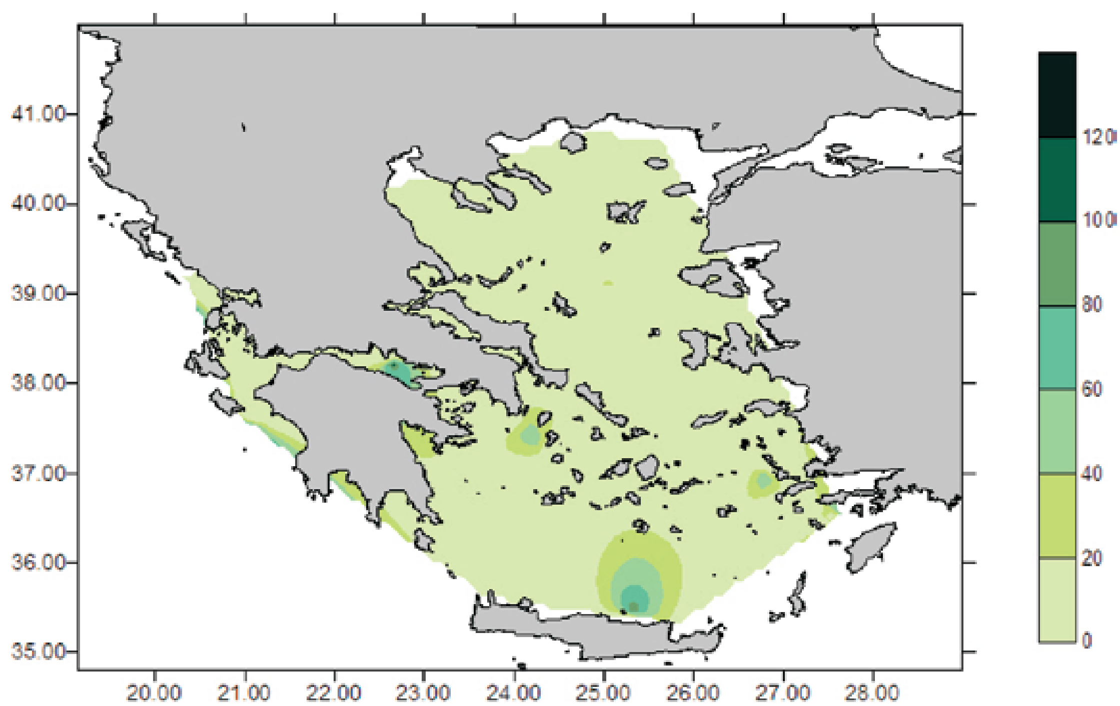

Figure. 1: Distribution pattern of *Galeus melastomus* in the Aegean Sea, based on the extrapolation of estimated abundance indices (kg/Km^2) from the MEDITS surveys in 2004-2005. (Source: HCMR, unpublished data).

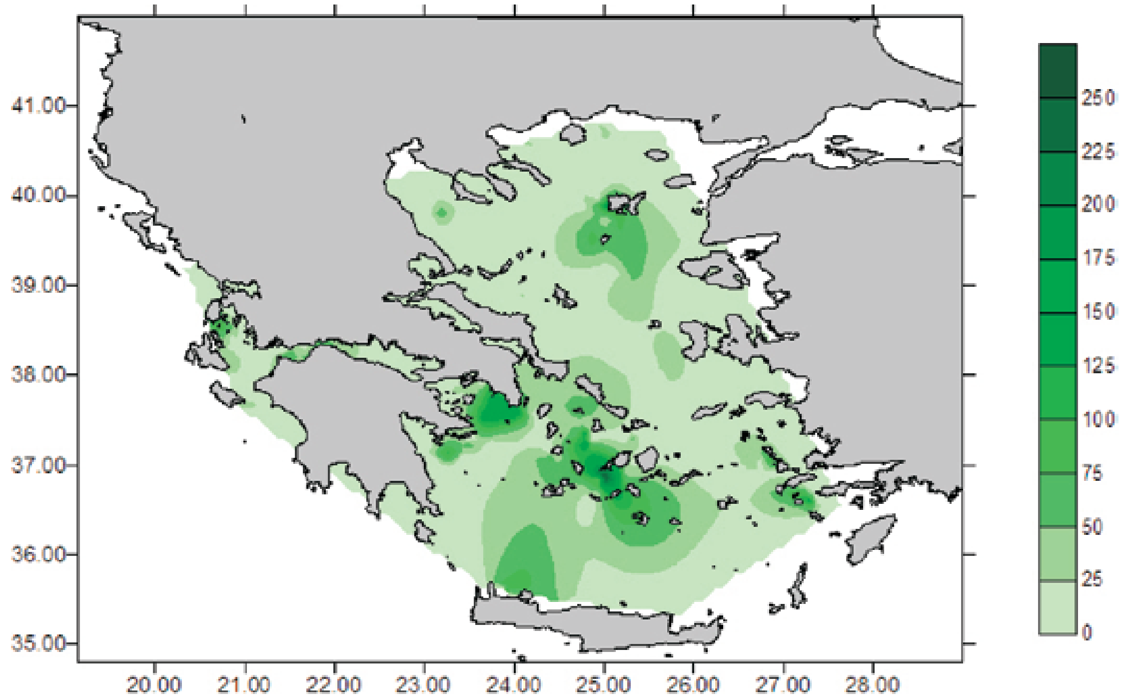

Figure 2: Distribution pattern of *Raja clavata* in the Aegean Sea, based on the extrapolation of estimated abundance indices (kg/Km^2) from the MEDITS surveys in 2004-2005. (Source: HCMR, unpublished data).

iorhinus canicula (TSERPES & PERISTERAKI, 2002). The results suggested the existence of a generally increasing trend for *Squalus acanthias*, while no significant trend was observed for *Scyliorhinus canicula*.

In the frame of a small-scale national project (Pythagoras II, University of Athens), aiming to study the impact of certain fisheries on demersal sharks, the most commonly caught shark species have been recorded and various aspects of their biology and fisheries have been examined. The list of the most common species includes: *Scualus acanthias, Squalus blainvillei, Scyliorhinus canicula, Galeus melastomus, Etmopterous spinax, Dalatias licha, Heptranchias perlo, Mustelus mustelus, Oxynotus centrina* and *Centrophorus granulosus* (MEGALOFONOU, 2005).

In the frame of the aforementioned project, the reproductive biology of a very common species, the spiny dogfish, *Squalus acanthias*, was studied and findings indicated that Mediterranean individuals reach maturity at a smaller length than the Atlantic ones. Fecundity rates were also lower than those reported in the Atlantic (CHATZISPYROU & MEGALOFONOU, 2005). Study of the egg case of a dogfish revealed that it forms a complex composite with extraordinary mechanical and functional properties and it is largely made of an analogue of the mammalian collagen (ICONOMIDOU *et al.*, 2007).

A local study aiming to examine mercury concentrations in edible tissues of spiny dogfish *(Squalus acanthias)* and smooth-hound shark *(Mustelus mustelus)* by means of Cold Vapor Atomic Absorption Spectrometry revealed that for most dogfish specimens, concentration levels were higher than those established by EU Decision 93/351 (MEGALOFONOU, 2005; COUSTENI *et al.*, 2006).

PELAGIC SPECIES

Pelagic elasmobranch species are incidentally caught in surface drifting long lines targeting swordfish and tunas. Until, 2001, information on pelagic elasmobranchs has originated from six EU projects aiming at the monitoring of large pelagic fisheries and one by-catch study. Since 2002 pelagic shark catches are regularly monitored in the frame of the National Fisheries Data Collection Programme.

The main species caught in the large pelagic fisheries are the blue shark (*Prionacea glauca*) and the pelagic sting ray (*Dasyatis violacea*) (DAMALAS & MEGALOPHONOU, 2003, TSERPES *et al.,* 2006; TATAMANIDES *et al.,* 2006). The devil fish (*Mobula mobular*), great white shark (*Carcharodon carchari-*

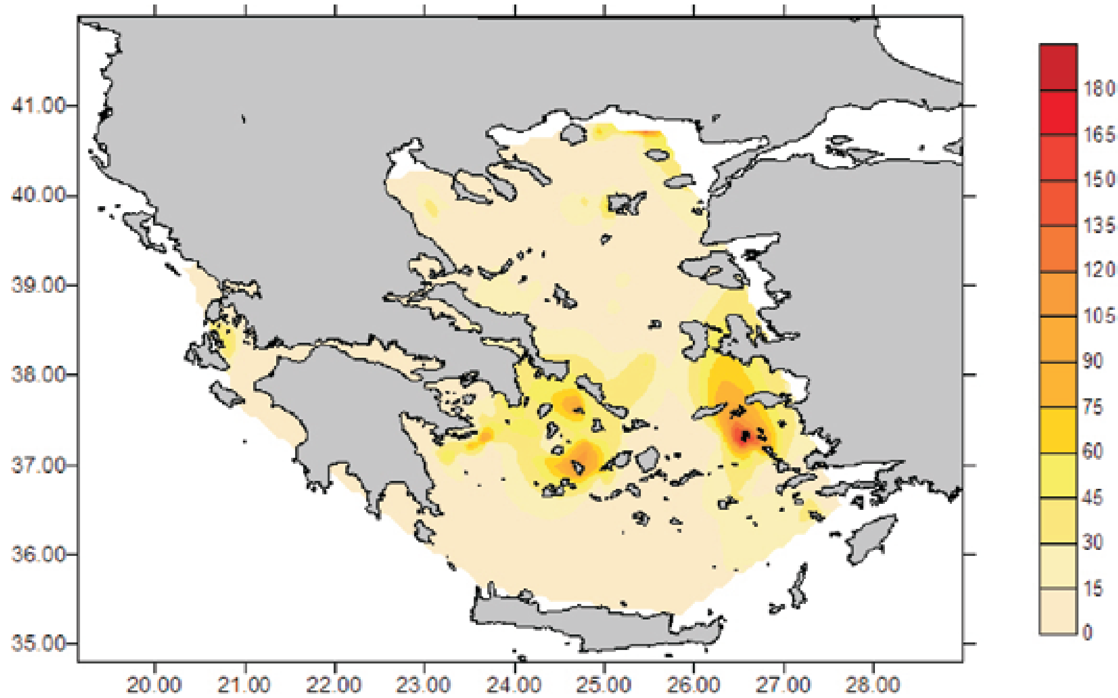

Figure 3: Distribution pattern of *Scyliorhinus canicula* in the Aegean Sea, based on the extrapolation of estimated abundance indices (kg/Km^2) from the MEDITS surveys in 2004-2005. (Source: HCMR, unpublished data).

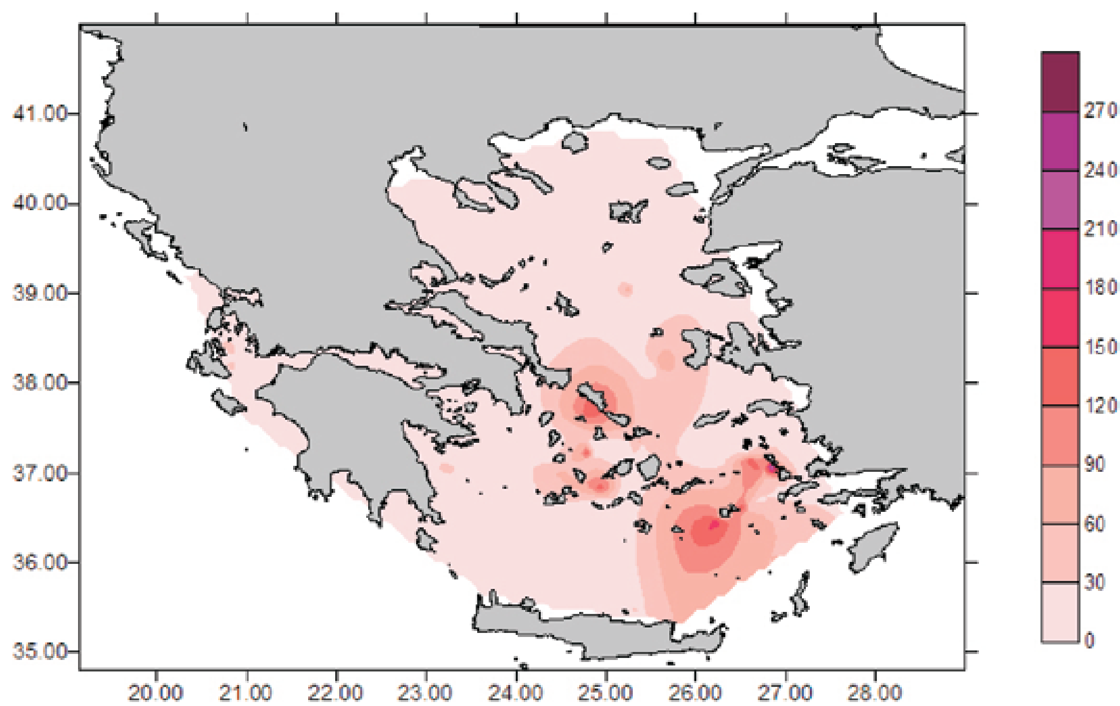

Figure 4: Distribution pattern of *Squalus acanthias* in the Aegean Sea, based on the extrapolation of estimated abundance indices (kg/Km^2) from the MEDITS surveys in 2004-2005. (Source: HCMR, unpublished data).

as), smooth hammerhead (*Sphyrna zygaena*), thin-tail thresher *(Alopias vulpinus)*, short-finned mako (*Isurus oxyrhinchus*) and tope shark (*Galeorhinus galeus*), have been also recorded as incidental catches (HCMR, unpublished data). Rare records of the big-eyed thresher shark, *Alopias superciliosus,* the sharpnose sevengill shark, *Heptranchias perlo,* the big-eyed sixgill shark, *Hexanchus nakamurai* and the sixgill shark (*Hexanchus vitulus*) have been also reported (MEGALOFONOU *et al.,* (2005a,b).

In the frame of the project "By-catches and discards of sharks in the large pelagic fisheries in the Mediterranean Sea" (No 97/50), annual catches of large pelagic sharks have been estimated to range from 48 to 123 tons, for the period 1998-2000. Catch comparison among the examined fisheries revealed higher shark catches in the swordfish fishery reaching a 3.8% in terms of total number of fish and 3.6% in terms of total biomass. In the albacore fishery shark catches were lower (2.2% in number and 0.9% in kg). Analysis of catch composition of the swordfish fishery 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%) (MEGALOFONOU *et al.,* 2000).

Analysis of the data collected in the frame of the National Fisheries Data Collection Programme has shown that the annual production of pelagic sharks in the 2004-2006 period ranged from 13 to 17 tones of fillet weight (ANONYMOUS, 2005; 2006; 2007).

Spatiotemporal variations in shark by-catches of the Hellenic swordfish long line fishery operating in the eastern Mediterranean were examined by means of Generalised Linear Modelling techniques applied to presence-absence and catch per unit effort data, collected from 2000 to 2003 through onboard sampling. Results revealed significant, monthly and area variations, while the yearly pattern was stable. Higher abundance indices were observed in the Levantine basin and in the waters around Kriti; concerning season, the higher values were observed in February, March and August (Figure 5). It is likely that these variations are related to the reproductive and feeding behaviour of the species (TATAMANIDES *et al.,* 2006). Results, also, demonstrated that the higher incidence of sharks in the catches is expected in February and July (Figure 6), (TSERPES *et al.,* 2006).

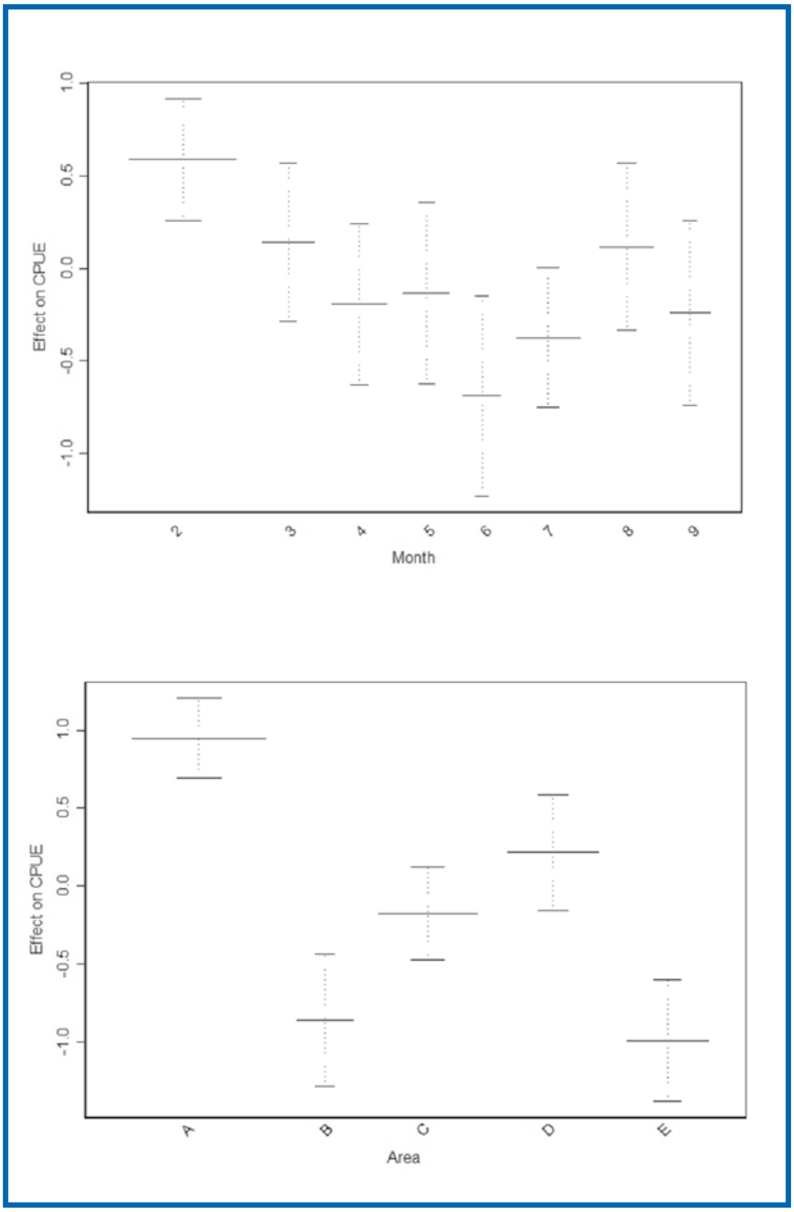

Figure.5: Generalized linear model derived significant effects of month and area on CPUE index of elasmobranch species. Each plot represents the contribution of the corresponding variable to the fitted predictor. The fitted values are adjusted to average zero and the broken lines indicate two standard errors. Bar widths correspond to the observation frequency at each variable level. Months: 2-9 February-September, A=Cretan Sea, B=Kyklades, C=Dodekanisos, D=Levantine. (Source: TATAMANIDES *et al.,* 2006).

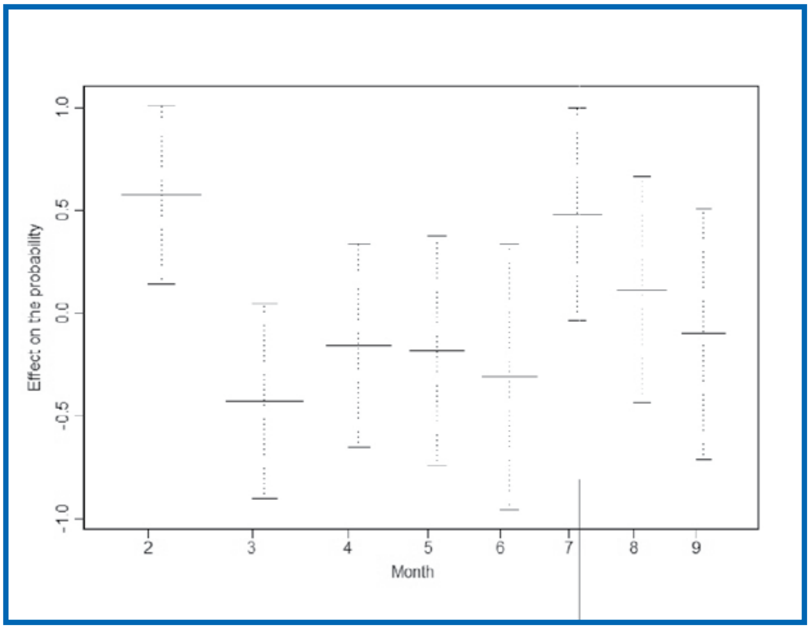

Figure 6: GLM derived effect of month on the probability to catch sharks. The fitted values are adjusted to average zero and the broken lines indicate two standard errors. Bar widths correspond to the observation frequency at each variable level. Months 2-9: February-September. (Source: TSERPES *et al.,* 2006).

FUTURE RESEARCH NEEDS-KNOWLEDGE GAPS

Extended monitoring of commercial fisheries capturing sharks is necessary for stock assessment studies. It should be noted, that as most pelagic elasmobranches are landed decapitated, finned and usually skinned, it is difficult to identify the species from landings and onboard sampling is needed.

Time series of data collected through experimental surveys such as the "MEDITS" can be used to establish population indicators for the monitored elasmobranch species and can provide valuable information for management purposes. Most shark species are highly migratory; hence stock boundaries extend beyond national borders. Consequently, international cooperation is needed to optimize research on those species. Since there are serious uncertainties regarding migration patterns and stock structure of pelagic sharks, research on these aspects (e.g. tagging operations, genetic studies, etc.) is necessary to achieve rational management of those resources. In addition, there is need for further research on the biology of the species mainly focusing on growth and maturity studies.

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