OILFISH AND SHARK BY-CATCHES OF THE GREEK SWORDFISH FISHERY IN THE E. MEDITERRANEAN: A PRELIMINARY ANALYSIS APPLIED TO "PRESENCE-ABSENCE" DATA

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SUMMARY

Spatio-temporal variations in shark and oilfish by-catches of the Greek swordfish longline fishery operating in the E. Mediterranean were examined by means of Generalized Linear Modeling techniques applied to "presence-absence" data collected from 2000 to 2003. Regarding oilfish, analysis revealed significant yearly, monthly and area variations, while the presence of sharks had a more stable pattern, showing significant variations only in terms of month.

RÉSUMÉ

Les variations spatio-temporelles des prises accessoires de requins et de rouvets de la pêcherie palangrière grecque ciblant l'espadon et opérant dans la Méditerranée orientale ont été étudiées à l'aide des techniques du Modèle linéaire généralisé (GLM) appliquées aux données de « présence-absence » collectées entre 2000 et 2003. En ce qui concerne le rouvet, l'analyse a révélé d'importantes variations annuelles, mensuelles et spatiales alors que la présence des requins présentait un schéma plus stable, n'affichant des variations importantes qu'en termes de mois.

RESUMEN

*Se examinaron las variaciones espaciotemporales en las capturas fortuitas de tiburón y escolar (*Ruvettus pretiosus*) de la pesquería griega de pez espada al palangre que opera en el Mediterráneo oriental mediante técnicas de modelación lineal generalizada, aplicadas a los datos de "presencia-ausencia" recopilados desde 2000 hasta 2003. En cuanto al escolar, los análisis revelaron importantes variaciones anuales, mensuales y zonales, mientras que la presencia de tiburones exhibe un patrón más estable, con importantes variaciones sólo en términos de mes.*

KEYWORDS

Swordfish, By-catch, Sharks, Oilfish, Mediterranean

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1 Introduction

Swordfish *(Xiphias gladius)* is a large pelagic species of high commercial value heavily exploited all over the Mediterranean basin. Greece is among the most important swordfish producers in the Mediterranean having an annual production of about 2000mt in the latest years.

Greek swordfish fisheries exploit the eastern part of the Mediterranean basin covering a large area, extending from the east Ionian to the Levantine seas. Fishing is carried out using drifting surface long-lines through February to September while is prohibited by a national regulation from October to January. Bluefin tuna is a secondary target of the fishery while the main bulk of by-catch is composed of oilfish *(Ruvettus pretiosus)* and various shark species (unpublished data).

The main objective of the current work is to examine spatiotemporal variations in oilfish and shark by-catches of the aforementioned fishery in the eastern Mediterranean.

2 Materials and Methods

The data collection scheme was based on representative sampling of fishing boats landing their catches on the main landing ports of the Aegean, Cretan and Levantine seas (**Figure 1**). For both oilfish and sharks the data that were analysed included information regarding their presence or absence in the catches on a trip basis. A total of 636 records were available that covered the fishing seasons of 2000 to 2003.

The obtained Bernoulli-type 0/1 measurements (0 for absence, 1 for presence) were analysed by means of Generalised linear modelling (GLM) techniques (McCullagh and Nelder 1983) assuming a binomial error structure model and a logit link function. The model included year, month and area as main effects. Model fitting was accomplished with the statistical package S-plus, following the approaches described by Venables and Ripley (1997).

3 Results

Analysis of deviance demonstrated that in the case of oilfish all effects were significant on the 95% level while in the case of sharks only the month effect was significant (**Tables 1** and **2**). For both species the effect of the significant predictors on the probability to catch the corresponding species is shown on the y-axis for different values of the predictor (x-axis) (**Figures 2** and **3**). Negative values on the y-axis indicate that at the corresponding levels of the predictor, the model estimates probabilities that are lower from the mean estimated by the model, while the opposite holds for positive values on the y-axis. In that sense, results demonstrate that the probabilities to catch oilfish are higher from May to July in the Aegean and Levantine seas and in terms of years were higher in 2002. Concerning sharks, the higher incidence in the catches is expected in February and July.

4 Discussion

The examined species are highly mobile, thus it is expected that their catches will show spatiotemporal variations. In the case of sharks, it was not easy to identify them on a species basis as they are mostly landed as fillets. However, on board observations suggest that the majority of shark catches are composed of the blue-shark *Prionace glauca* (unpublished data). Hence, it is likely that the observed monthly variations in shark occurrence reflect seasonal movements of that species, similar to those reported for the open oceans (see Bigelow et al. 1999). Such movements have been related to the reproductive and feeding behaviour of the species (Nakano 1994). Blue-shark has been also reported as a common by-catch species of the swordfish fishery in the western Mediterranean (Mejuto et al. 2002).

Information on the biology and ecology of oilfish is limited to few reports about its occurrence and diet (Nakamura and Parin 1993); hence only speculations can be made regarding the observed spatiotemporal variations in the species distribution pattern. However, findings from similar studies on the Spanish Mediterranean swordfish fishery (Mejuto et al. 2002) indicate that this species is much more common in the eastern part of the basin.

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Table 1. Analysis of deviance table for the GLM model fitted to the *Ruvettus pretiosus* presence-absence data. (d.f. =degrees of freedom, Res. =Residual).

Source of variation	d.f.	Deviance	%Explained	Res. d.f.	Res. Deviance	Probability (Chi)
Null				635	831	
Year	3	79	9.6	632	752	<0.001
Month	7	32	3.9	625	719	<0.001
Area	4	57	6.8	621	661	<0.001
Total		168	20.3			

Table 2. Analysis of deviance table for for the GLM model fitted to the shark presence-absence data (d.f. =degrees of freedom, Res. =Residual).

Source of variation	d.f.	Deviance	%Explained	Res. d.f.	Res. Deviance	Probability (Chi)
Null				635	713	
Year	3	2	0.3	632	711	0.570
Month	7	15	2.2	625	696	0.032
Area	4	6	0.7	621	689	0.201
Total		23	3.2			

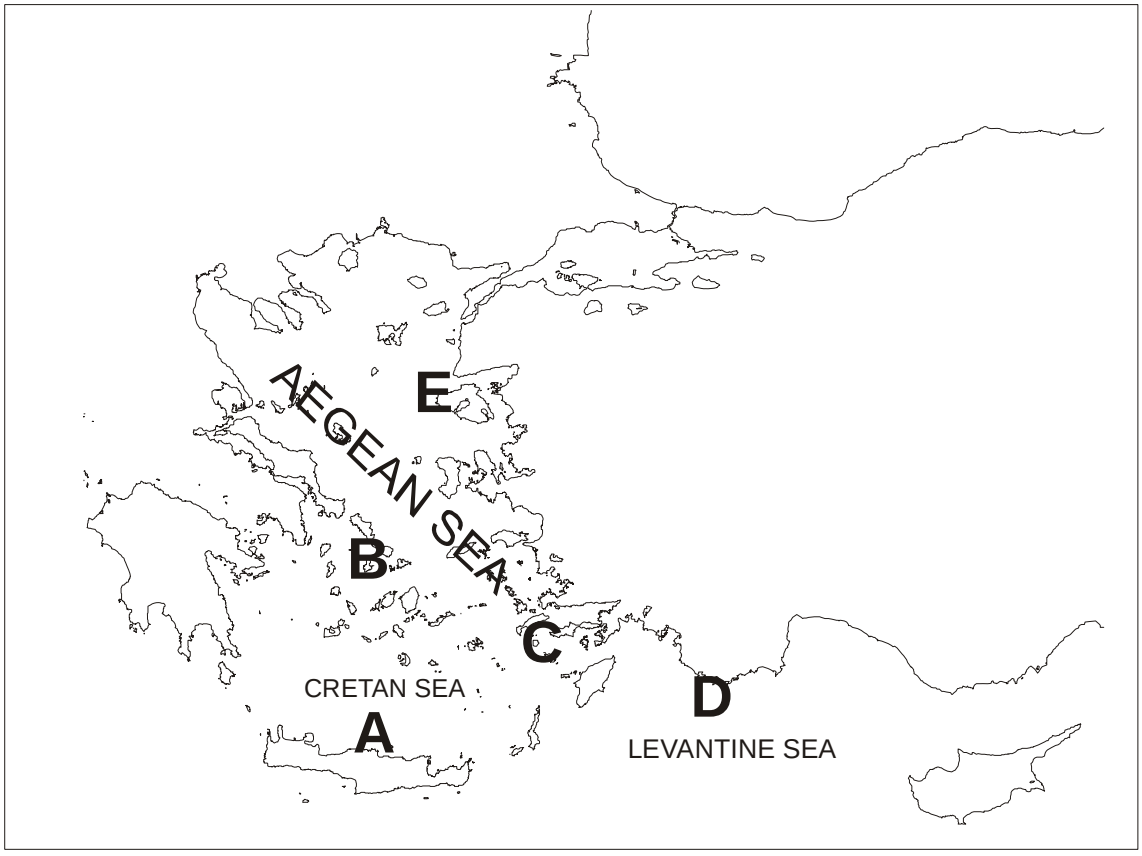

Figure 1. Graph indicating the main areas exploited by the studied fleets. A = Cretan sea, B = Central Aegean, C = Southeastern Aegean, D = Levantine, E = North Aegean Sea.

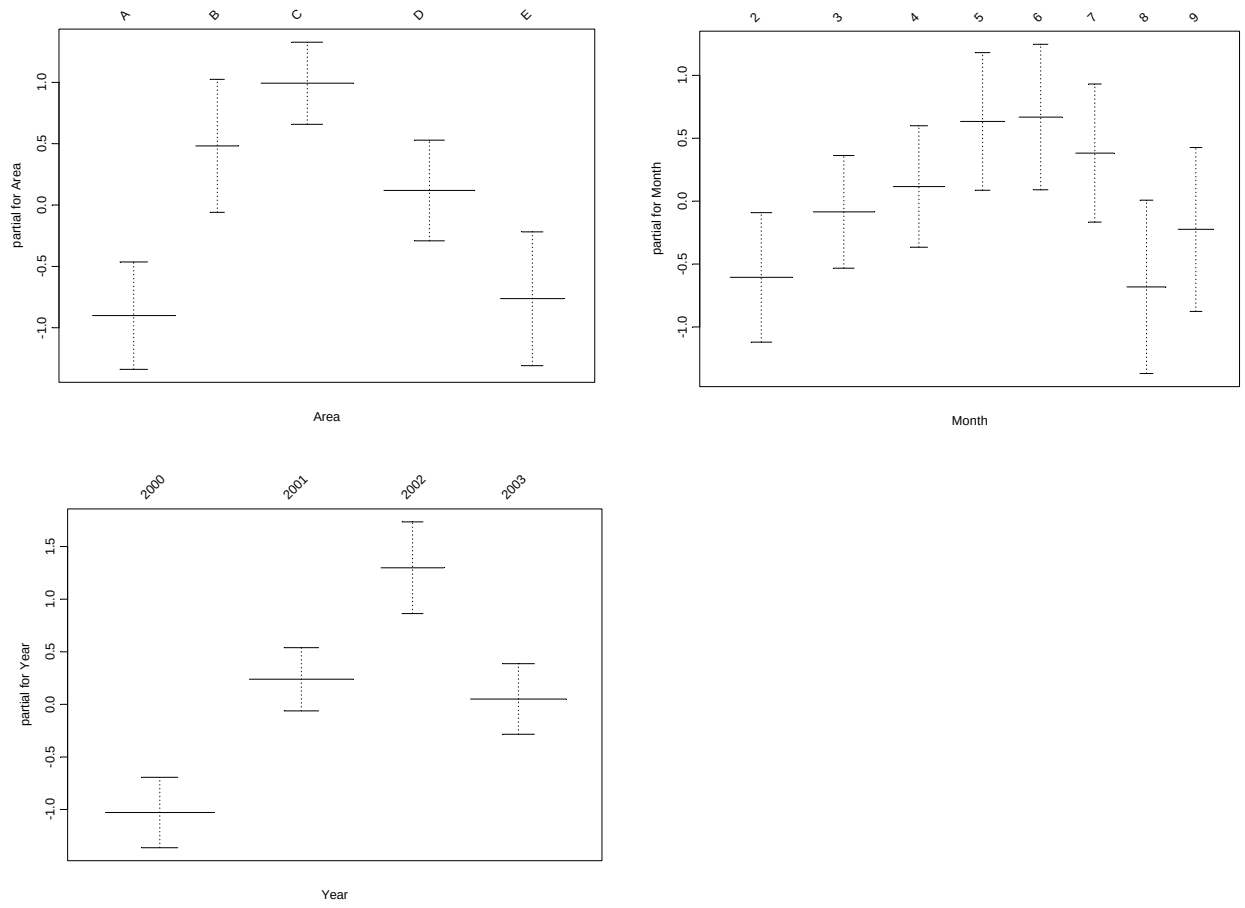

Figure 2. GLM derived significant effects on the probability to catch oilfish. Each plot represents the contribution of the corresponding variable to the fitted predictor. The fitted values are adjusted to average zero and the broken lines indicate two standard errors. Bar widths correspond to the observation frequency at each variable level. Months: 2-9 February-September. Areas: A = Cretan sea, B = Central Aegean, C = Southeastern Aegean, D = Levantine, E = North Aegean Sea.

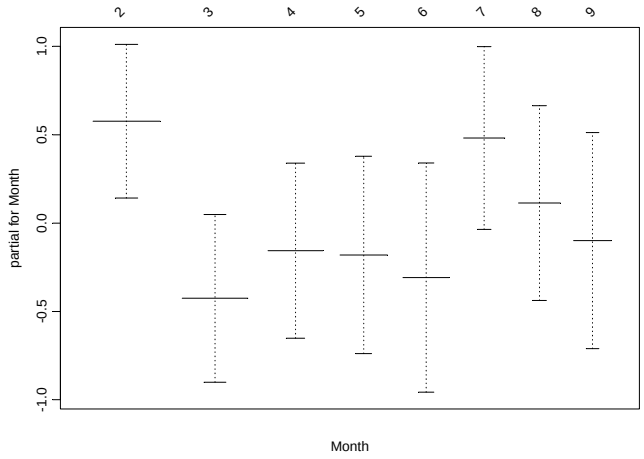

Figure 3. GLM derived effect of month on the probability to catch sharks. The fitted values are adjusted to average zero and the broken lines indicate two standard errors. Bar widths correspond to the observation frequency at each variable level. Months: 2-9 February-September.