SWORDFISH ABUNDANCE TRENDS IN DRIFTING SURFACE LONGLINE GREEK FISHERIES

George Tserpes[1], Panagiota Peristeraki[1]

SUMMARY

*Indices of abundance of swordfish (*Xiphias gladius*) from the Greek drifting surface longline fisheries targetting swordfish in the eastern Mediterranean are presented for the period 1987-2015. Annual standardized indices were estimated by means of Generalized Linear Modeling techniques and the predictor variables included the Year, Month, Gear type and Area of fishing. In addition catchability changes occurred in the fisheries were also taken into account. CPUE differences were found to be statistically significant for all predictors examined and the standardized annual indices from 2000 onwards are generally lower than those estimated for the previous years.*

RÉSUMÉ

*Les indices d'abondance de l'espadon (*Xiphias gladius*) des pêcheries grecques opérant à la palangre dérivante de surface ciblant l'espadon dans l'Est de la mer Méditerranée sont présentés pour la période comprise entre 1987 et 2015. Les indices annuels standardisés ont été estimés au moyen des techniques de modélisation linéaire généralisée et les variables de prédiction comprenaient l'année, le mois, le type d'engin et la zone de pêche. En outre, les changements de capturabilité survenus dans les pêcheries ont également été pris en compte. Les différences de CPUE se sont avérées statistiquement importantes pour tous les prédicteurs examinés et les indices annuels standardisés à partir de 2000 sont généralement plus bas que ceux estimés pour les années antérieures.*

RESUMEN

Se presentan los índices de abundancia del pez espada (Xiphias gladius) de las pesquerías griegas de palangre de deriva de superficie que se dirigen al pez espada en el Mediterráneo oriental durante el periodo 1987-2015. Se estimaron índices estandarizados anuales por medio de técnicas de modelación lineal generalizada y las variables de predicción incluían año, mes, tipo de arte y zona de pesca. Además, se tuvieron en cuenta los cambios adicionales en la capturabilidad ocurridos en las pesquerías. Se halló que las diferencias en la CPUE eran estadísticamente significativas para todos los valores de predicción examinados y los índices estandarizados anuales desde 2000 en adelante eran por lo general menores que los estimados para los años previos.

KEYWORDS

Swordfish, Mediterranean, Catch/effort

[1] Hellenic Centre for Marine Research, P.O. Box 2214, 71003 Iraklion, Greece. E-mail: gtserpes@hcmr.gr

1. Introduction

Swordfish *(Xiphias gladius)* is a commercially important migratory fish heavily fished in the Atlantic and Mediterranean. According to ICCAT records, Greece is among the three most important swordfish producers in the Mediterranean and the Greek swordfish fisheries exploit the eastern part of the Mediterranean basin covering a large area, extending from the east Ionian to the Levantine seas. The gear used is drifting surface long-lines and two different longline types are used: the Classical and the "so-called" American, owing its name to its similarity to the longline used for tuna fishery in the Atlantic. The American type gear is set deeper than the traditional and always employs fluorescent material to attract the fish. Nowadays, the American type longline is employed by the vast majority of the fishermen.

The main goal of the present work was to estimate annual standardized abundance indices based on commercial catch per unit effort (CPUE) data series obtained from Greek fleets exploiting the Aegean Sea and the eastern Levantine basin. In the current work we attempt to update the previously estimated series (Tserpes & Peristeraki, 2015) using additional fisheries data, and considering a series of factors that would potentially affect catch rates. Data analysis has been accomplished by means of widely used Generalised Linear Modelling (GLM) techniques.

2. Materials and Methods

Data have been collected in the frames of past European and national projects and included spatial and temporal information on catch and effort in as much as possible detail, i.e. on an individual boat trip basis. CPUE observations were expressed in terms of kg/1000 hooks as it commonly adopted in ICCAT. Sampling, which was based on on-board observations and information from landings on the major (pilot) landing ports, covered the activities of the Greek fishing vessels exploiting different areas of the eastern Mediterranean from 1987-2015 **(Figure 1).**

The collected data covered the activities of the two main swordfish fleets operating in the country, the fleets of Kalymnos and Hania. Generally, catches of both fleets represent 50-70% of the total Greek production (Tserpes *et al.* 2002). These fleets mainly exploit the central, south-eastern Aegean Sea but occasionally extend their activities to the northern Aegean and Levantine basin. Fishing is mainly carried out using drifting surface long-lines through February to September as it prohibited by national law from October to January and recently there have been established the additional ICCAT closures. Since the late 90's the fishing vessels started progressively to use a modified version of the traditional long lines, similar to that employed for the tuna fishery in the Atlantic. The modified gear, which is known as American-type longline, differs from the traditional one as regards the length and diameter of mainline and branch lines, as well as, the distance between branch lines. Moreover, it is usually set deeper than the traditional one and always uses fluorescent material to attract the fish. Nowadays, most boats involved in the fishery on a systematic basis are using the American gear and even vessels using the traditional gear are also employing fluorescent material.

Past studies have demonstrated catchability differences among the two longline types, with the American gear been much more effective than the traditional one (Tserpes and Peristeraki 2004). Besides, based on literature information and discussions with fishers it was assumed that the use of light-sticks on the traditional gear doubles its catchability. The nominal CPUE data were analyzed, by means of GLM techniques (McCullagh and Nelder 1983) using the "MASS" package under the R language environment (R Development Core Team 2013). Based on the deviance residuals plots of preliminary runs, and similarly to the previous analysis (Tserpes & Peristeraki, 2015) a negative binomial error structure model with a log link function was assumed.

The predictor variables included in the model were year, month, area, gear as main effects, as well as, the second order interactions between all predictors except the "year". Interaction terms including the "year" effect were not examined as they may bias the year effect standardized estimates.

Thus, the general form of the GLM used was:

$$CPUE \sim c + Year + Month + Area + Gear + Month{:}Area + Month{:}Gear + Area{:}Gear + e$$

where c = constant and e = error term

All statistical inference was based on the 95% confidence level.

3. Results and discussion

A total of 4815 data records were analysed, which were collected in the period 1987-2015 with the exception of 1989, 1996 and 1997. Five fishing areas were considered: A = Cretan sea, B = Central Aegean, C = South-eastern Aegean, D = Levantine and E = North Aegean (see also **Figure 1**). There is no any outstanding feature in the deviance residual plot suggesting that the model is inappropriate for the observations (**Figure 2**). The analysis of deviance table indicated that all effects were significant on the 95% statistical level **(Table 1)**.

The standardized model estimates of CPUE by year are given in **Table 2** and illustrated in **Figure 3.** Although CPUE levels show large fluctuations over the examined years a decreasing trend, which is stabilized from 2005 onwards is generally observed when a smoothing line is fitted to the standardized model estimates and their confidence intervals (**Figure 4**).

References

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Table 1. Analysis of deviance table for the GLM model fitted to the long-line CPUE data from the Greek fleets.

Source	**LR Chisq**	**Df**	**Pr(Chisq)**
Year	700.71	25	<0.001
Month	109.14	7	<0.001
Area	72.96	4	<0.001
Gear	707.80	1	<0.001
Month:Area	83.52	28	<0.001
Month:Gear	28.61	7	<0.001
Area:Gear	25.33	4	<0.001

Table 2. Standardized model CPUE estimates (kg/1000h) by year.

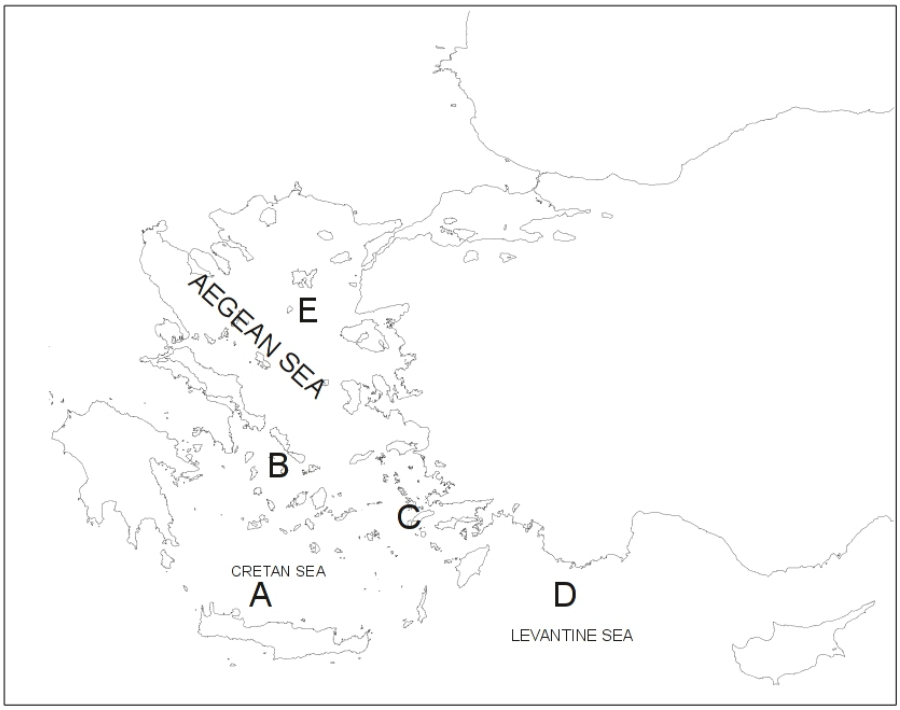

Figure 1. Map of the eastern Mediterranean indicating the main areas exploited by the studied fleets. A = Cretan sea, B = Central Aegean, C = Southeastern Aegean, D = Levantine and E = North Aegean.

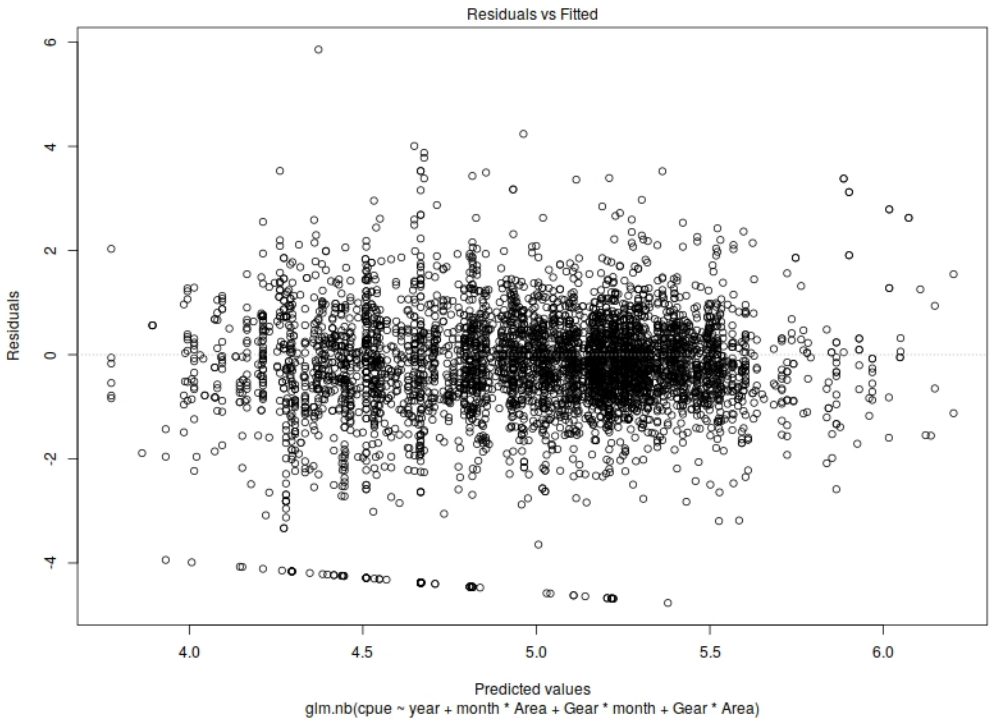

Figure 2. Residual deviance plot of the generalized linear model fitted to Greek long-line data.

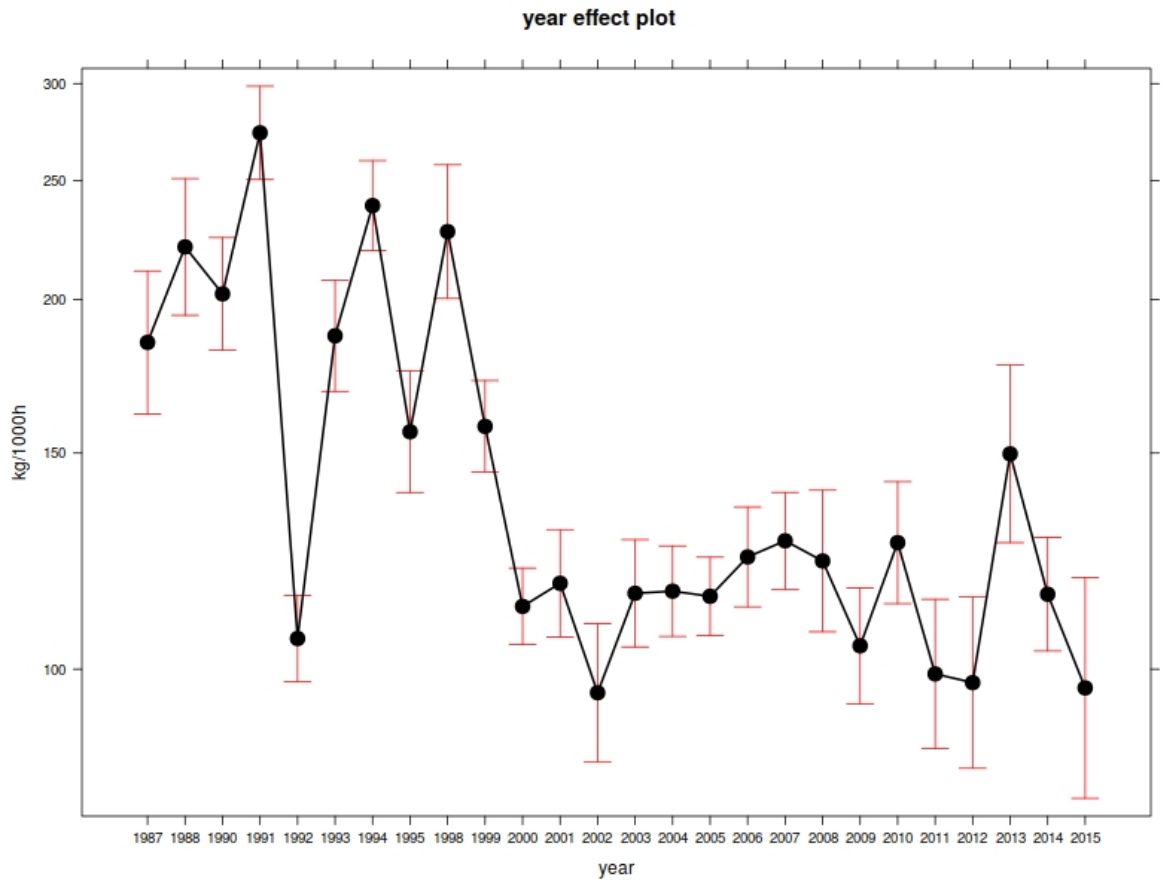

Figure 3. GLM derived standardized CPUE estimates by year. Vertical lines indicate the 95% confidence intervals of the corresponding estimates.

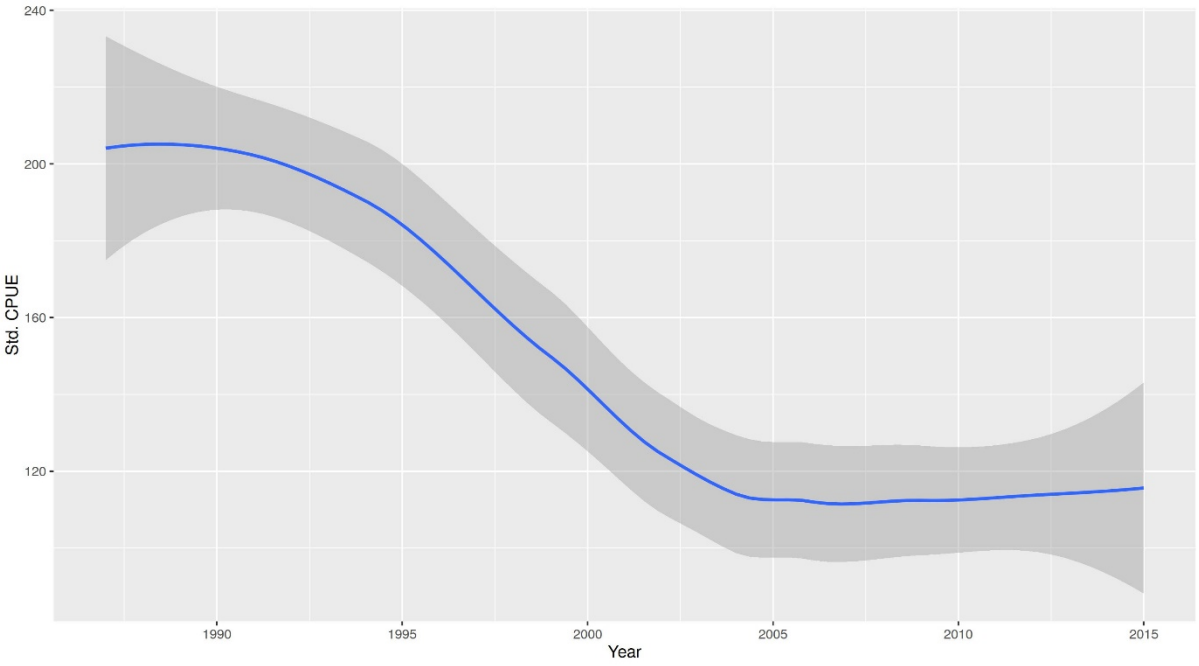

Figure 4. Smoothing line along with its confidence intervals fitted to the mean, lower and upper CPUE model estimates by year.