INFLUENCE OF ENVIRONMENTAL FACTORS ON SWORDFISH CATCH RATES IN THE EASTERN MEDITERRANEAN SEA

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Abstract

The influence of environmental and operational parameters on swordfish longline catch rates in the Eastern Mediterranean Sea was investigated applying a generalized additive model. The model indicated seven factors (longitude, sea surface temperature, latitude, bathymetry, distance from coastline, fishing gear and month), which influence either swordfish relative abundance or vulnerability. Spatial and operational factors played predominant role in the model, while environmental features were subsequent constituents. Lunar index was excluded from the analysis as insignificant to the convergence of the model. Higher catch rates were observed in greater longitudes and lower latitudes and for SST from 16 to 21° C.

Keywords: swordfish, generalized additive models, long-line, catch rates, fisheries oceanography

Introduction

Broadbill swordfish, *Xiphias gladius*, is a large pelagic, oceanic species with worldwide distribution and high commercial value. Environmental influence on distribution and abundance of swordfish resources is an important factor that should be included in fisheries management models (1,2,3). In this study, we present a preliminary attempt to examine the relative influence of various environmental and operational factors on the swordfish longline catch rates in the Eastern Mediterranean Sea.

Materials and methods

During 1998-2001, catch and effort data from the Greek swordfish long-line fishery were collected by observers along with spatio-temporal, oceanographical and operational data. A stepwise fitted (in a forward and backward manner) generalized additive model (GAM) was applied to quantify the influence of the various factors on swordfish catch rates (2). Initially nine variables were included in the analysis: satellite-derived estimates of SST at the fishing location, a lunar index based on the illuminated percentage of the moon's face, the distance from coastline, the bathymetry at the fishing location, the latitude, longitude, month, fishing gear type (American or traditional swordfish longline) and sampling method (on-board or at landing). Catch-per-unit-effort (CPUE) was expressed in number of fish per 1000 hooks. Since the histogram of nominal CPUE values was not normal (n=15 zero data points), in our link function ($\log_e$), we assumed that the underlying probability distribution was a Poisson distribution. Spans of the locally weighted polynomial scatterplot smoothers (*loess*) were set to 0.25 (25% of surrounding data) in order to avoid rough and bumpy responses that became apparent when using a span of 0.1. The independent variables were incorporated in the model in the following form:

$$\log_e(\text{CPUE} + 0.1) =$$
$$c + lo_1(\text{longitude}) + lo_2(\text{SST}) + lo_3(\text{latitude}) + lo_4(\text{bathymetry}) + lo_5(\text{distance from coastline}) + \text{fishing gear type} + lo_6(\text{month}) + lo_7(\text{lunar index}) + \text{sampling (on-board, at landing)} + e,$$

where c is a constant, lo_i(variable) is a *loess* smoother function of the *i*-studied variable and e is a random error term.

Results and discussion

A total of 594 observations of swordfish longline sets were roughly distributed from 19 to 34°E and from 32 to 40°N. GAM indicated that longitude had a profound effect on catches explaining more than 36% of the deviance in swordfish CPUE. Sea surface temperature (10.4%) and latitude (6.2%) were the next most influential parameters, while bathymetry (4.1%), distance from coastline (2.2%), fishing gear (1.3%) and month (1.0%) played a minor role. In total, the derived model explained more than 61% of the variance in swordfish CPUE. Lunar index and sampling were non-significant covariates. Similar results were obtained for the commercial swordfish longline fishery in the Atlantic Ocean (4).

Higher CPUE values in greater longitudes and lower latitudes (Fig. 1) corresponded to the Levantine region where exploitation rates for large pelagic fish were quite low compared to the rest of the Mediterranean till recently (5). Therefore, it was deduced that higher catch rates in this area might indicate higher swordfish abundance.

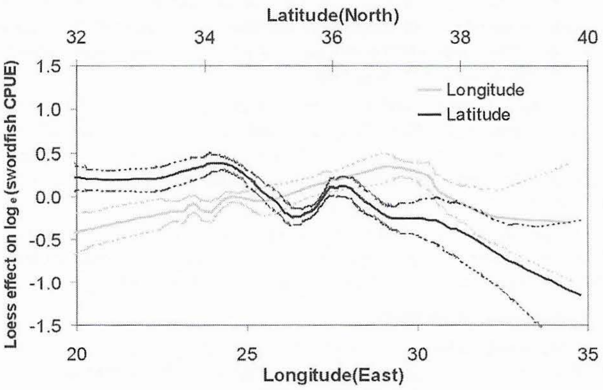

Fig. 1. GAM derived effect of Longitude and Latitude on swordfish nominal CPUE deviance (log transformed). Dashed lines: 95% confidence bands.

Abundance related to SST fluctuated through the temperature range studied, however higher CPUE values were observed in temperatures from 16 to 21°C. Moreover, CPUE related to both distance from coastline and bathymetry displayed no noticeable trends. Monthly allocation of catch rates revealed that September is accompanied with increased abundance. Probably the recruitment of juveniles in the longline fishery affects the rising of CPUE values during September.

The effect of fishing gear alone on swordfish catch rates was low but significant. The use of fish attractant chemical light-sticks and thicker (more resilient) line are reasonable explanations for the increased catches of the "American type" swordfish longline when compared to the traditional one. We assumed that this variable reflects the catchability of the species rather than the abundance.

Given that our GAM analysis covers a few years and a small number of variables, it may be immature to draw strong inferences regarding environmental effects on swordfish distribution and abundance. Nevertheless, our preliminary results indicated that spatio-temporal and operational factors played the predominant role in the model (explaining more than 44% in total CPUE deviance), while the environmental features were subsequent constituents (17%).

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