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Using ecosystem indicators to predict abundance of jack mackerel stock in Korean waters

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Introduction

Jack mackerel, *Trachurus japonicus* that migrate throughout warm water are distributed widely around Korean waters, especially in the entire continental shelf in the southern Japan/East Sea (JES), the Yellow Sea (YS) and the East China Sea (ECS) (Zhang & Lee, 2001). Spawners in the middle of ECS have been known to occupy large catches and to be related to the abundance of jack mackerel in Korean waters. Considering that this species distributes and spawns in the southern Korean water and ECS (Zhang *et al.*, in press), the abundance strength of jack mackerel in relation to oceanographic conditions, such as variability in potential larval transport and seawater temperature in their habitats, was discussed in this study.

The objective of this study was to utilize the ecosystem indices to evaluate hypotheses linking jack mackerel abundance to ecosystem and to predict the jack mackerel abundance around Korean waters.

Data and Methods

To analyze seasonality in monthly distributions of jack mackerel, we calculated confocal ellipses and centroids in the fishing ground of this species in Korean waters. The catches by fishing block of jack mackerel from the Korean large purse seine fisheries in Korean waters were based on Fisheries Resources Research Database (FIRRD) in the National Fisheries Research and Development Institute (NFRDI) of Korea.

The analyses in this study focused on the relationships between jack mackerel abundance and environmental variables in Korean waters. We used correlation and generalized additive modeling (GAM) to build models of mackerel abundance in relation to catch index, ocean surface current and sea surface temperature (SST).

A generalized additive model (GAM; Hastie & Tibshirani, 1990) was used to explore relationships between fish abundance and environmental variables. Analysis of deviance was applied to compare models. The Akaike Information Criterion (AIC; Akaike, 1973) was used to compare non-nested models. AIC penalises the use of additional degree of freedom for increasing the goodness of fit. Models were compared according to their AIC values: a better model has a lower AIC.

Results and Discussion

The habitat of jack mackerel showed seasonality with spatial variations during the periods between from December to July and from August to November in Korean waters. While the first habitats were formed eastward from the longitude line of 127°30'E, the second were formed westward. The annual catch of this species also had seasonality with spring season at 25% and fall season at 16% of average fishing seasons from 1988 to 2002. Annual catch of this species was over 20 thousand mt every 2 or 3 years in Korean waters during the period of 1988 to 2002. Those years had good spring fishing season of April and May, except for 1989 and 1997, when with good fall fishing season of September and October, instead. The high abundance of jack mackerel was determined by the abundance of spring season with threshold of 6 thousand mt in the same year, when the body length of this species was larger than that of the average abundance years.

We identified the catches in spring fishing seasons during the period of 1988~2002, except for fall seasons in 1989 and 1997, as Successful catch index (SCI), which was correlated with SST in April inside centroids of the joint confidence regions in the abundance distributions of jack mackerel ($r=0.444$, $P<0.05$). Therefore, SST in spawning season inside centroids of abundance distribution and ocean surface current by the Ocean Surface Current Simulation (OSCURS) model can be ecological indicators for jack mackerel around Korean waters.

The bivariate GAM models were developed to explore relationships between jack mackerel abundance, catch index and environmental variables. Fitted models of log abundance as a function of catch index and environmental variable were presented in this study. Regressions of log abundance against catch index and SST had better fit and lower AIC than those to either catch or environmental variable alone. The best model in terms of AIC was model 4 with lowest AIC of 3.80 and highest r^2 of 0.92, in which log abundance was regressed against catch index and SST. The best models (with the lowest AIC and the highest r^2) provided a good fit to the abundance data, except for 1989 and 1996. Correlation coefficient between observed and predicted abundance was very significant ($r=0.959$, $P<0.001$).

This approach provides better evaluations of jack mackerel stock with ecosystem approaches to fisheries to the Korean stock assessment and fisheries evaluation (SAFE) for the TAC-based fisheries management system.

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