The relationship between Albacore (Thunnus alalunga)catch rate and marine environmental variance in the Indian Ocean using GAM and HSI model

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ABSTRACT

Albacore tuna (*Thunnus alalunga*) is one of the important commercial species of the Taiwanese longline fishery in the Indian Ocean. The purpose of this study was to investigate the relationship between environmental variations and catch rates to explore the underlying processes influencing albacore distributions and habitat in the Indian Ocean. Using the Generalized Additive Model (GAM) and Habitat Suitability Index (HSI) model, and its impacts of fishing condition possibly influencing by the climate scenarios. The results of the cumulative deviances by the selected GAM were 69.6%, positive association between catch per unit effort (CPUE) and sea surface temperature between 17-21 ℃, sea surface high of 0.4–0.6 m, net primary production around 250-450 mg C/m^2d^1 and mixed layer depth within 60-120 m in the Indian Ocean. HSI model also underpinned that albacore have high sensitivity to the habitat changes in its ocean environments. Based on four climate scenarios (RCP2.6, RCP4.5, RCP6.0, and RCP8.5) from the low to high future carbon emissions in the period of 2015 to 2045, the CPUE was increased from 2.2 N/1000 hooks in years of 2015-2020 to about 4 N/1000 hooks in years of 2040-2045. In addition, the change of possible habit was also estimated.

I. INTRODUCTION

In the Indian Ocean, the state of the albacore tuna stock was previously elucidated (ICCAT, 2015); however, the biological and environmental influences on its movements and catch rates are still under investigation. The availability of oceanographic and biological information would improve fishing operations as well as the management of fishery resources. Furthermore, catch rate models that incorporate relevant variables associated with environmental variation can be used to infer possible factors influencing the distribution of highly migratory species, such as albacore tuna.

This study aimed to determine the association between environmental variations and catch rates to explore the underlying processes influencing the catch rates and distribution of albacore tuna in the Indian Ocean and accordingly predict the distribution. These functional associations can be used to evaluate the effects of climatic variability on the spatial pattern and vulnerability of albacore tuna.

II. DATA AND METHODS

This study used generalised additive models (GAMs) fitted to Taiwanese longline fishery data from 1998 to 2014 and investigated the association between environmental variables and catch rates to understand the processes influencing the albacore tuna distribution in the Indian Ocean .The GAM model formula is :

$$\boldsymbol{ln(CPUE + C) = \alpha + \sum_{i=1}^{n} S_i\,(X_i) + \xi} \quad (1)$$

Then used the Habitat Suitability Index (HSI) to detect the fishing ground of albacore tuna in Indian Ocean. The method of HSI model is Maximum Entropy (MAXENT).

Four of climate scenarios (RCP2.6, RCP4.5, RCP6.0, and RCP8.5) about SST, SSH, MLD and NPP values were downloaded from the Geophysical Fluid Dynamics Laboratory (http://www.gfdl.noaa.gov/).

III. RESULT AND DISCUSSION

The results revealed that the catch rates and distribution of albacore tuna were sensitive to environmental and climatic variation. The model selection processes showed that the selected GAMs explained 69.6% of the cumulative deviance in the entire Indian Ocean. Furthermore, the monthly time series of catch per unit effort (CPUE) indicated that the April to September are major fishing period (Fig. 1).

Environmental factors, the sea surface temperature (SST), substantially contributed to the explained deviance. The high CPUE occur in sea surface temperature between 17-21 ℃, sea surface high of 0.4–0.6 m, net primary production around 250-

450 mg C/m^{2}d^1 and mixed layer depth within 60-120 m in the Indian Ocean. HSI model also underpinned that albacore have high sensitivity to the habitat changes in its ocean environments (Fig. 2).

The result of GAM and HIS model in future climatic scenarios that the predicted albacore catch rate increase from 1998 to 2014.

IV. FUGURES AND TABLES

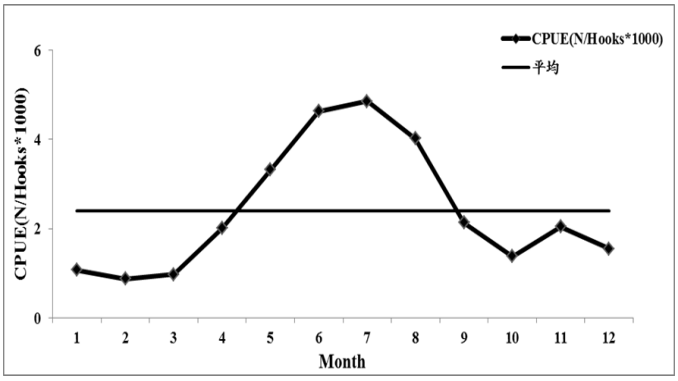

Figure 1. Monthly time series of CPUE of albacore tuna in Indian Ocean shows the major fishing period is from April to Septmber.

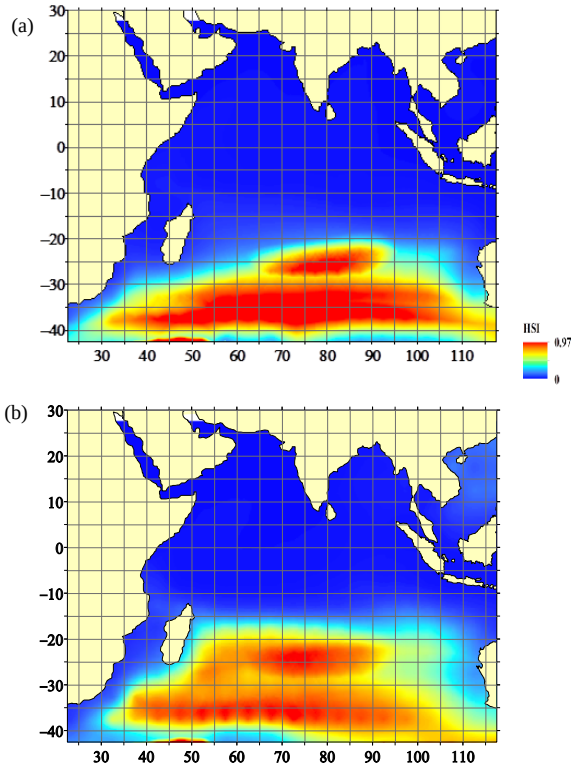

Figure 2. The suitable habitat of albacore (a) may to August (b) September to April by HIS model in Indian Ocean.