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Striped marlin CPUE standardization of Japanese longline fishery in North Pacific Ocean using a statistical habitat model[1)]

Minoru Kanaiwa[2)], Yukio Takeuchi[3)], Hirokazu Saito[3)], Hiroshi Shono[3)] and Kotaro Yokawa[3)]

2) Tokyo University of Agriculture
196 Yasaka, Abashiri, Hokkai 099-2493, Japan

3) National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu-ku, Shizuoka 424-8633, Japan

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Abstract

We estimated annual stock trend by using the statistical Habitat Model on the striped marlin CPUE obtained from the Japanese longline fishery in the North Pacific Ocean. We used and compared four types of data separation and two type of habitat preference, i.e. absolute depth and relative temperature. We could not find any significant difference between area separation ways. Southern annual trend was a little bit more optimistic than northern one by using either absolute depth or relative temperature as habitat preference. This is similar with GLM's data. Western annual trend was more optimistic than eastern one.

Introduction

Catch per unit effort (CPUE) is the most commonly used abundance index, but if fishing gear does not cover all habitat of target specie, nominal CPUE will not reflect abundance of stocks so we need to standardize it using information such as the habitat preference of the target species. The aim of our study is to explore how area-separation will affect to annual trend of stock abundance and habitat preference which way is best way to do it.

Data sets

Data from the Japanese longline fishery from 1952 to 2004 aggregated by month, 5-degree square and the number of hooks between floats (NHF) were used (about NHF data we have only after 1975).

We used absolute depth and seawater temperature difference relative to sea surface temperature (SST) as habitat information. We obtained temperature data from 1950 to 2001 from Simple Ocean Data Assimilation (SODA; Carton et al. 2000a, b: see http://www.meto.umd.edu/~carton/carton/ref.html). We obtained same type of data from NCEP for 2002 and 2003. We used the habitat information in 2003 as the one for 2004 in this time.

We limited the timeframe to the period between 1975 and 2004 to estimate both annual trend of stock abundance and the distribution of habitat preference because there are no NHF data prior to 1975. We estimated only annual trend of stock abundance between 1952 and 2004 by fixing the distribution of habitat preference which estimated by using the data from 1975 to 2004.

Our target area for this study is the North Pacific Ocean as shown by the heavy line in Fig. 1. We used 4 types of area separation (Figs.1-4).

Vertical distribution probabilities of striped marlin estimated using data collected by longline research (Yokawa et al. 2005) were used as a basic prior probability distributions. The CV is calculated by bootstrapping method (Yokawa et al. 2005).

Vertical distribution of gear expressed by catenary curve was calculated by theoretical equation depend on NHF (Yoshiwara 1951 and Suzuki et al., 1977).

Method

A statistical habitat based standardization (statHBS) (Bigelow et. al. 2004) allows parameter (e.g., habitat preferences and factors modifying the behavior of the gear or species) estimation based on the fit of the model to observed catch and effort data as well as oceanographic data. The habitat preferences in the habitat model (HBS) approach (Hinton and Nakano 1996) were used as priors in the statHBS within Bayesian context. Details of the statistical methodology can be found in Bigelow et. al. (2004).

We chose the annual trend of sCPUE and a habitat preference probability as the estimated parameters. To show area separation effect, sCPUE in the year of calculation is scaled to 1.0 and the values in other years are also scaled to the value relative to that of the first year. To compare with GLM's result we scaled data by average value for all year. In other word, we divided all value by average value.

We used 4 subarea stratifications (Figs. 1-4) but total areas are same. Area separation I is what we separated in subject way based on catch and CPUE distribution pattern (Fig. 1). From II to IV, we separated area by using regression tree analyses (Shono et. al. 2005). Area separation II is used CHAID and Third and Forth ones used CART (Figs. 2-4). The difference between third and forth one is when stop the separation.

Result and Discussion

First we will show the results using data from 1975 to 2004. Fig. 5 show estimated and prior distribution of habitat preference by using all data (i.e. no area separation). Absolute depth is used as habitat preference. It has two peaks and this may come from the discontinuity of the distribution of NHF. Figs. 6 to 9 show annual trend of sCPUE for each area separation rule, respectively and Figs. 6 to Fig. 8 we compare the result with GLM's one. The trend is almost same but if we dare to say something, statHBS showed more optimistic trend than GLM. If we use NHF effect to catch effort (Fig. 33) on GLM as weight factor, the difference may become small. We need to try it later. Figs. 10, 12, 14 and 16 show annual trends of sCPUE for each area by using each area separation rule, respectively. In southern area, trend looks more optimistic than northern one. Western areas have more optimistic trend than Eastern areas also (Figs. 10 and 14). Figs. 11, 13, 15 and 17 show prior and estimated distributions of habitat preference. Estimated habitat preference shows similar with prior one.

Fig. 18 show estimated and prior distributions of habitat preference. Relative temperature is used as habitat preference. This is estimated by using all data. Estimated one is almost same with prior one but it may look a little smoother. This may be more reasonable than to use absolute depth as habitat preference. Figures from 19 to 22 show annual trend of sCPUE. These have a little bit upward trend. Figs 23, 25, 27 and 29 show annual trends of sCPUE for each area by using each area separation rule. Southern area has more optimistic trend than northern one in contrast with the result using absolute depth as habitat preference. West area is more optimistic than east one. Figs. 24, 26, 28 and 30 show prior and estimated distributions of habitat preference. On northern area estimated distributions are more similar with prior ones than ones on southern area.

Figs. 31 and 32 show annual trend and sCPUE which are estimated using the data from 1952 to 2004 and fixed distribution of habitat preference estimated using the data from 1975 and 2004. Fig 31 uses absolute depth and Fig 32 uses relative temperature as habitat preference. The result using absolute depth is smoother than relative temperature's one. Both results have dump on 1975. It may show we cannot standardize correctly before 1975 because we don't have NHF data so we assume all NHF are same and 5 from 1952 to 1974. It may make some bios on estimation for the term. We need to estimate NHF by cluster analysis or other way. We don't say which habitat preference is best to standardize CPUE in this paper, because even if we can show one habitat preference is better than another one by using some way such as AIC, and if we will get some biological data which show inverse result, we should use that biological result.

Using absolute depth as habitat preference, the result becomes more similar with GLM's one than one using relative temperature but the difference is small. We can not reach final conclusion as to the best model or best area separation is best to standardize CPUE. To evaluate the performance of model and area separation, we recommend simulation work like using SEEPA. That is objective way to evaluate models and which information is the most important to estimate it. In same time, we should gather more biological data of habitat preference.

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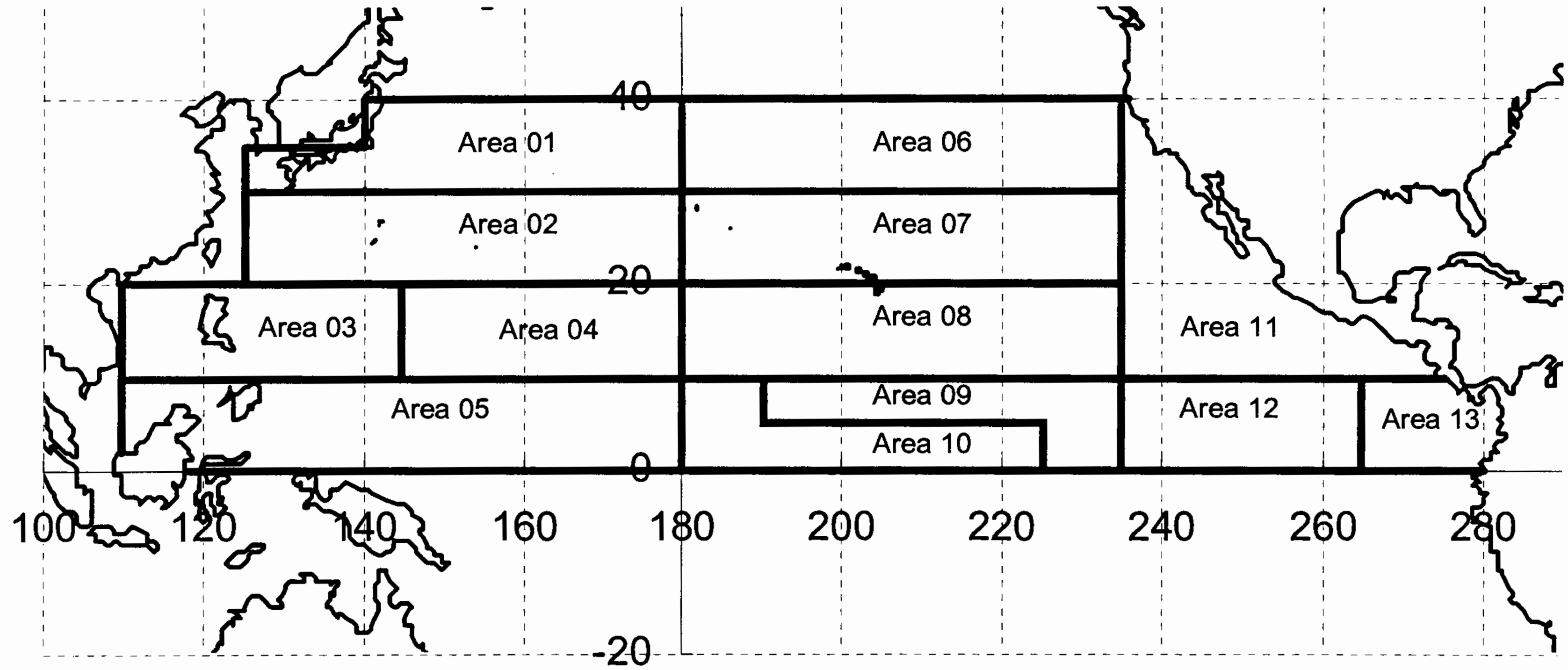

Fig. 1 Area separation I, this is separated in subject way based on catch and CPUE distribution pattern.

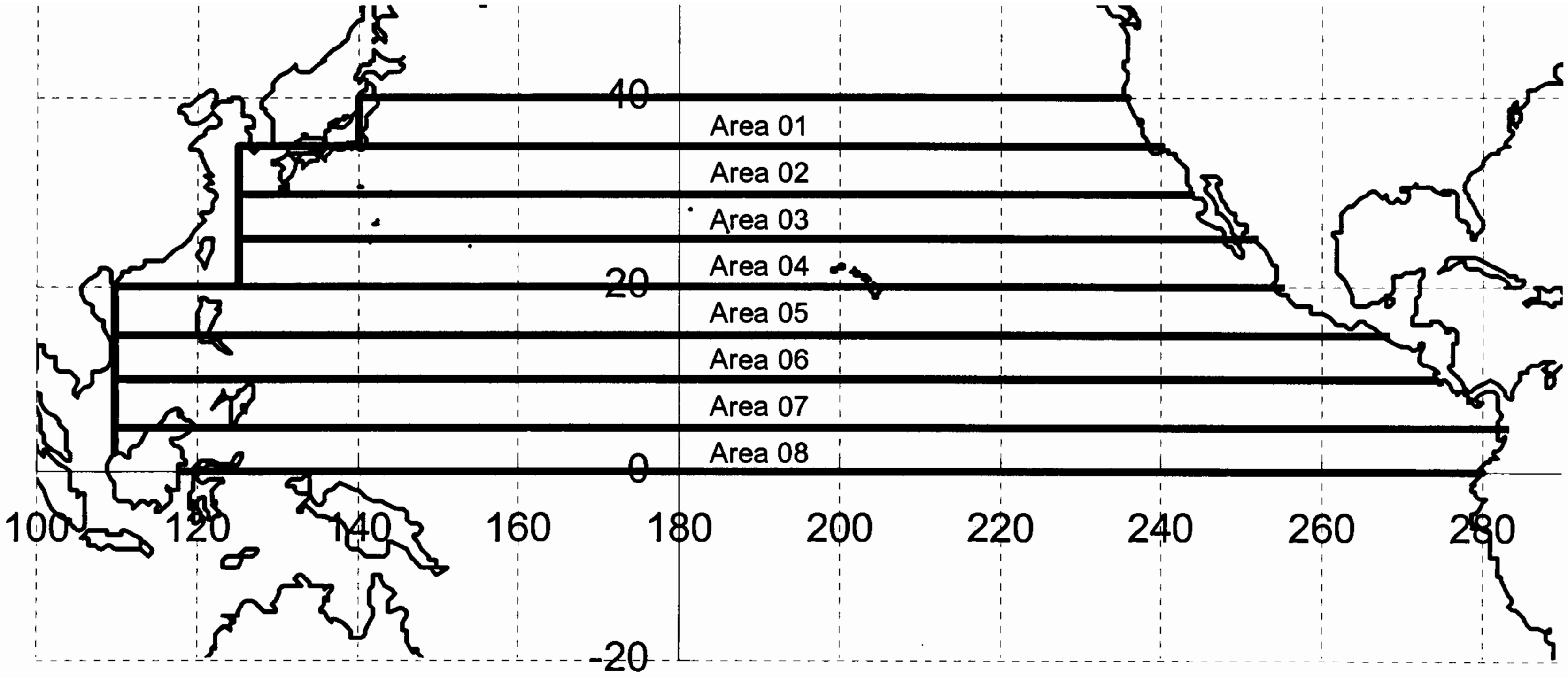

Fig. 2 Area separation II, this is separated by using regression tree with CHAID algorithm.

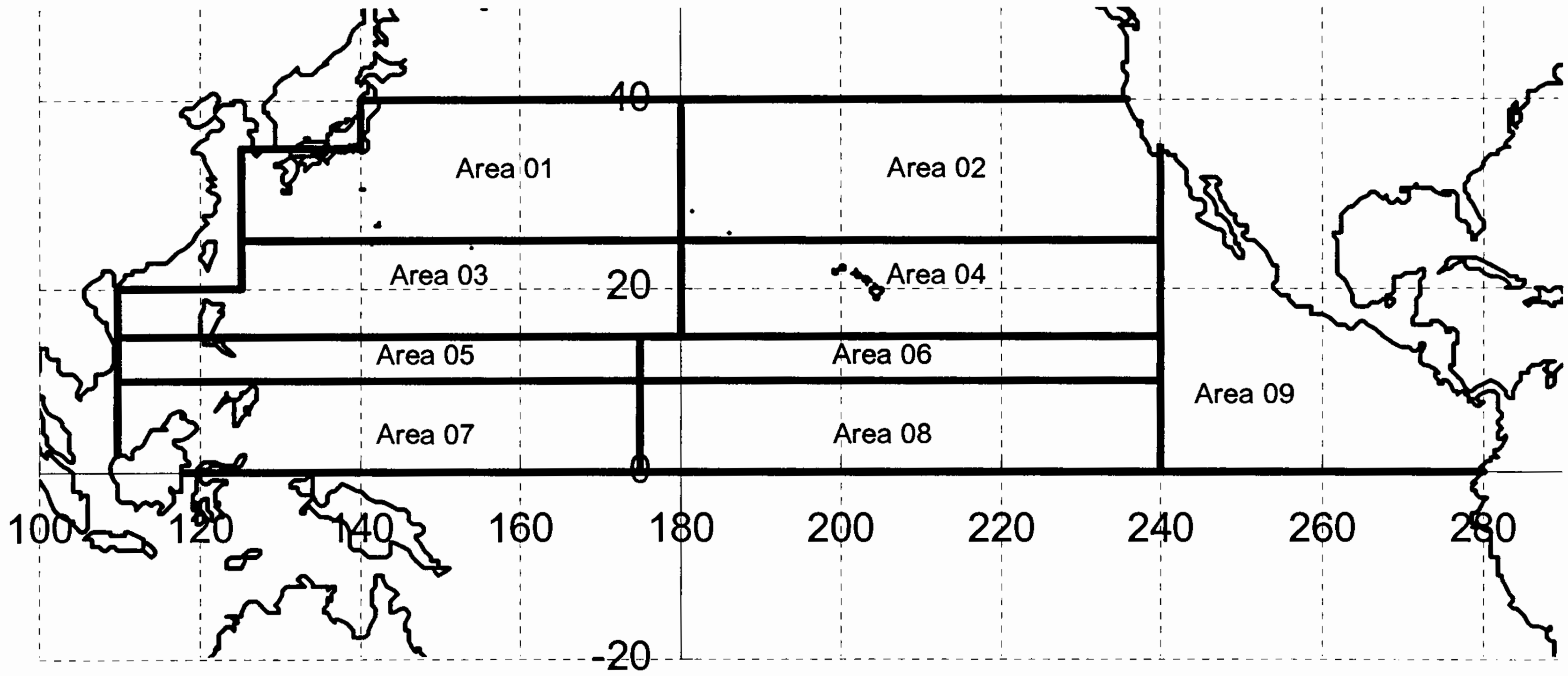

Fig. 3 Area separation III, this is separated by using regression tree with CART algorithm.

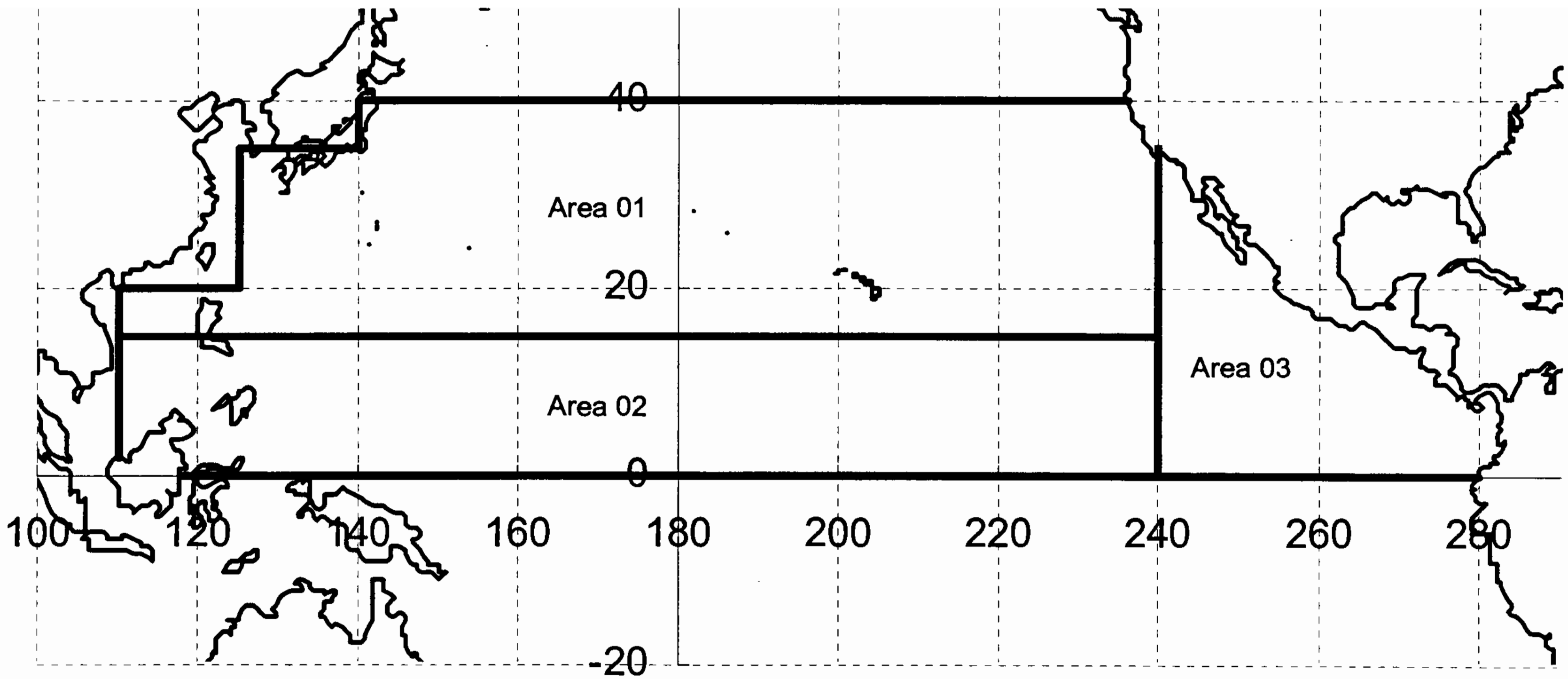

Fig. 4 Area separation III, this is separated by using regression tree with CART algorithm. This is stopped to separate on 2nd separation.

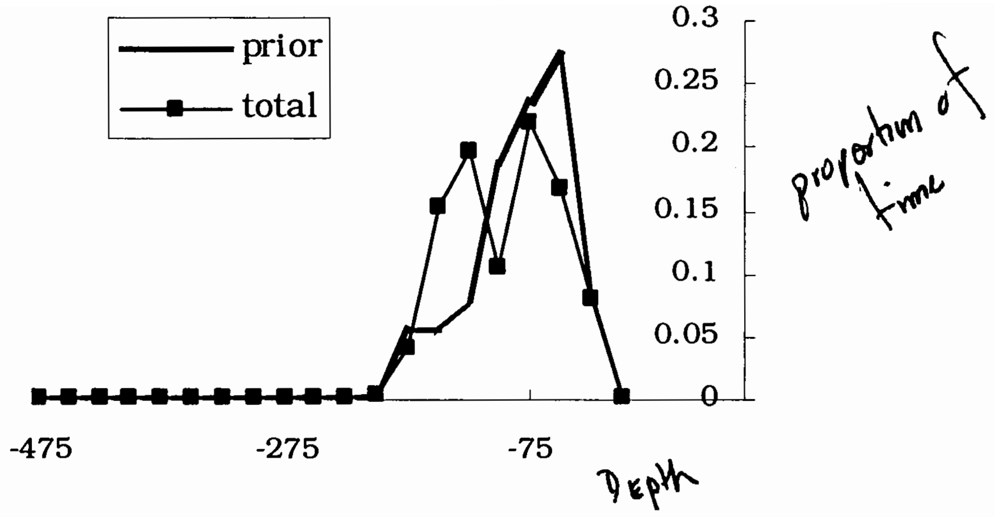

Fig. 5 Estimated and prior distribution of habitat preference on each absolute depth without any area-separation (c.e. using all data together).

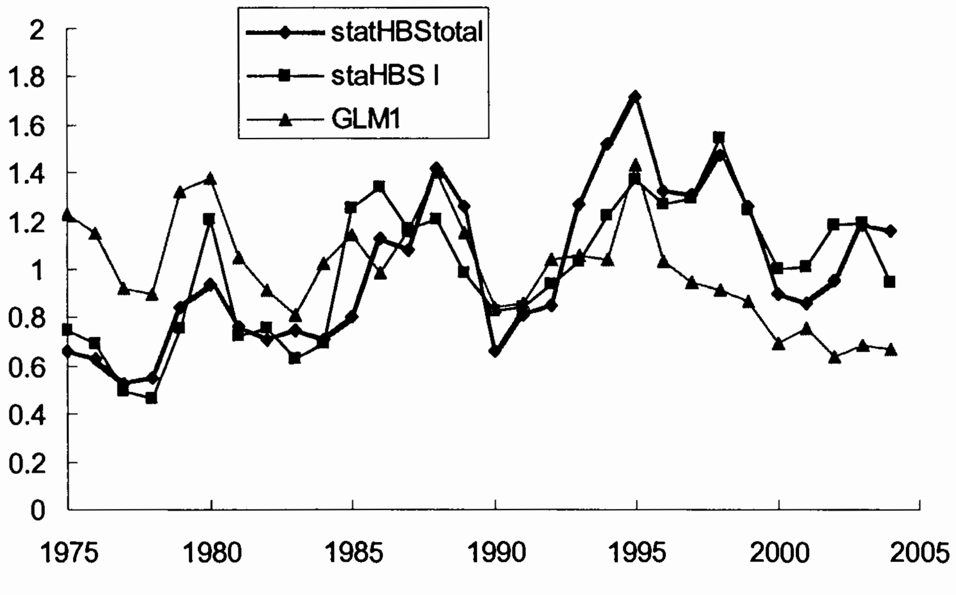

Fig. 6 Annual trend of sCPUE, statHBStotal is using all data together, statHBS I calculate annual trend separately followed by area-separation I, weighted by area dimension and summed up. GLM1 is calculated by using GLM with same area-separation. Absolute depth is used as habitat preference.

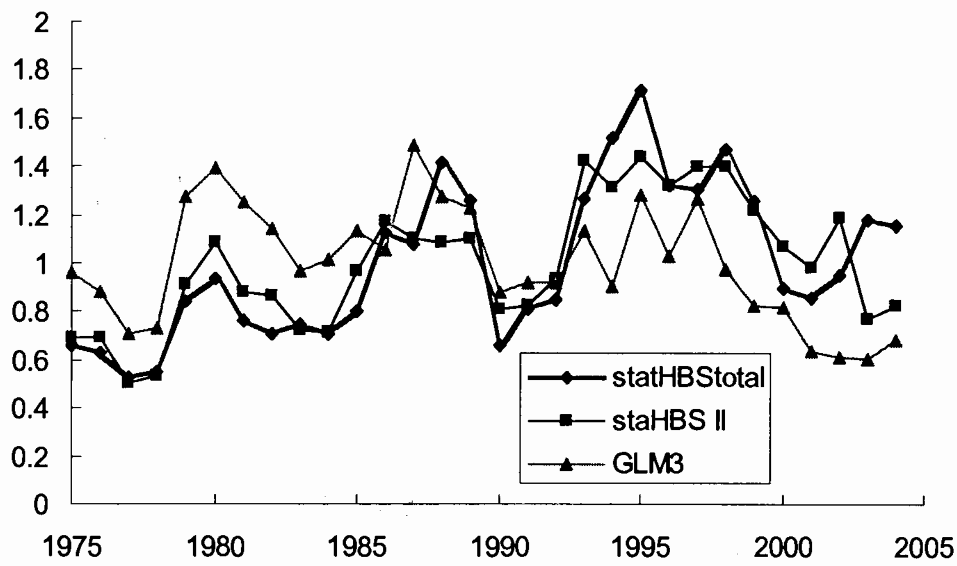

Fig. 7 Annual trend of sCPUE, statHBStotal is using all data together, statHBS II calculate annual trend separately followed by area-separation II, weighted by area dimension and summed up. GLM3 is calculated by using GLM with same area-separation. Absolute depth is used as habitat preference.

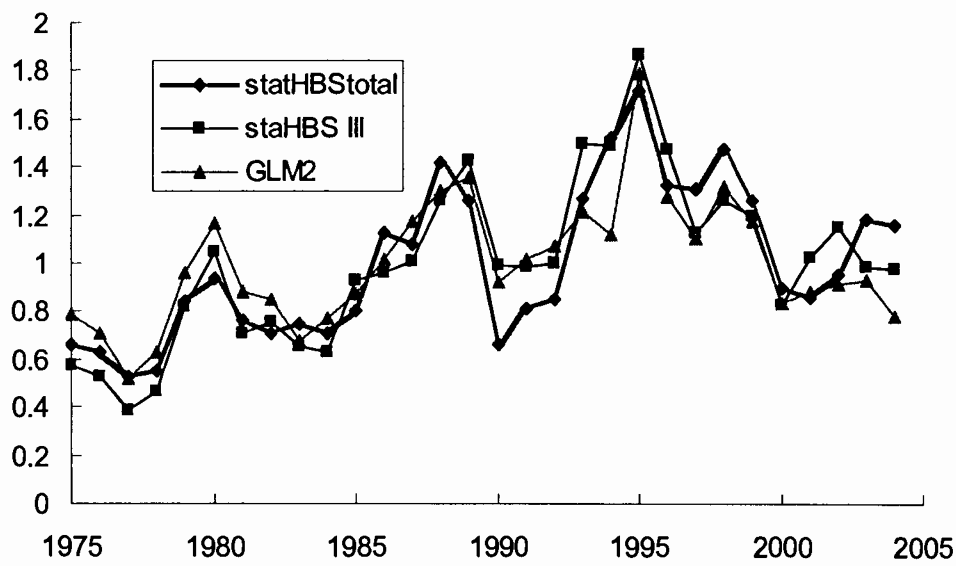

Fig. 8 Annual trend of sCPUE, statHBStotal is using all data together, statHBS3 calculate annual trend separately followed by area-separation III, weighted by area dimension and summed up. GLM2 is calculated by using GLM with same area-separation. Absolute depth is used as habitat preference.

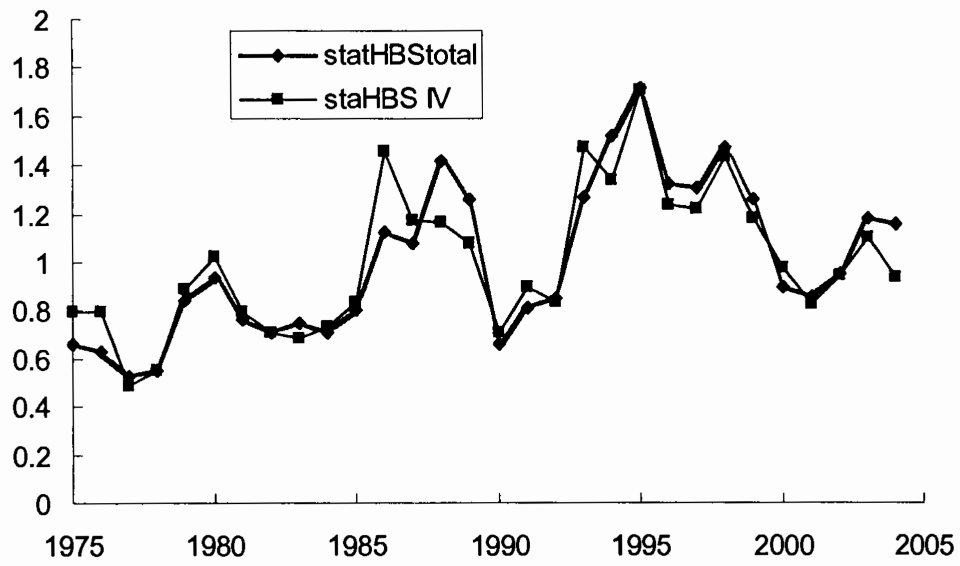

Fig. 9 Annual trend of sCPUE, statHBStotal is using all data together and statHBS IV calculate annual trend separately followed by area-separation IV, weighted by area dimension and summed up. Absolute depth is used as habitat preference.

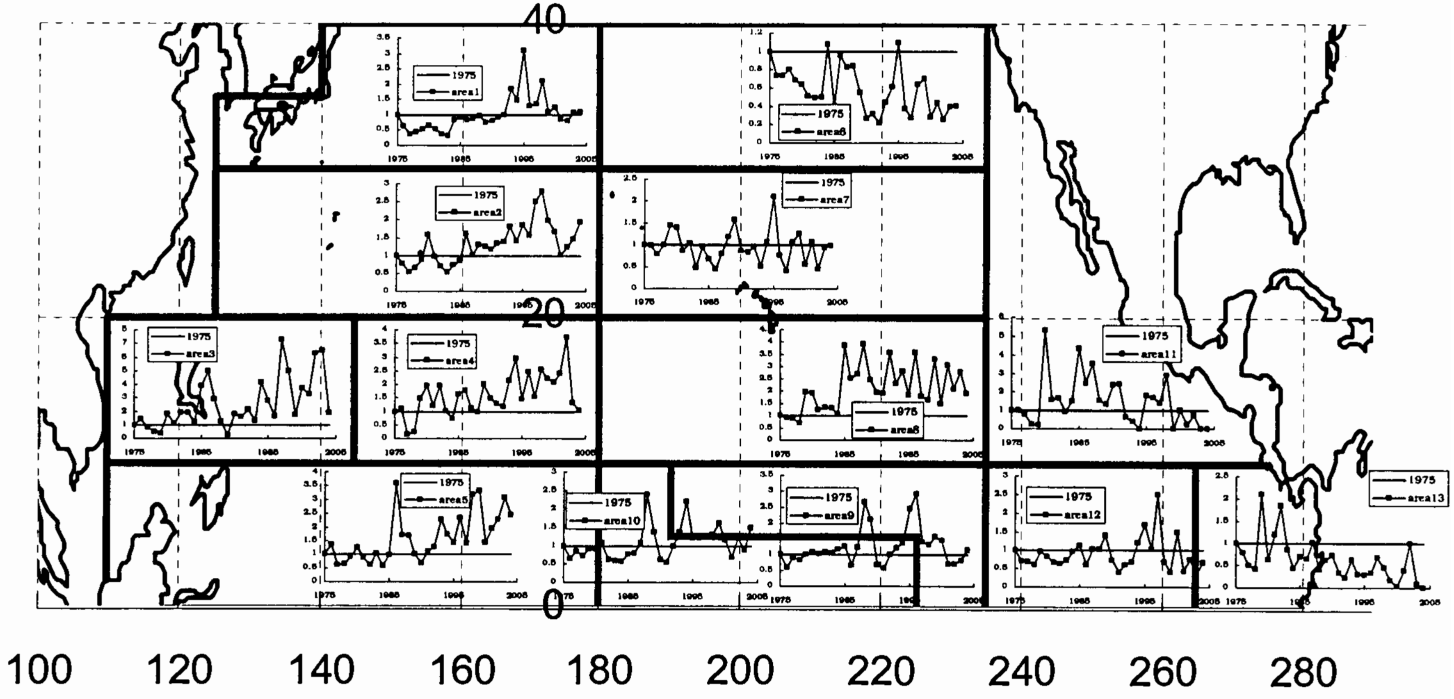

Fig. 10 Annual trend of sCPUE on area separation I. Absolute depth is used as habitat preference.

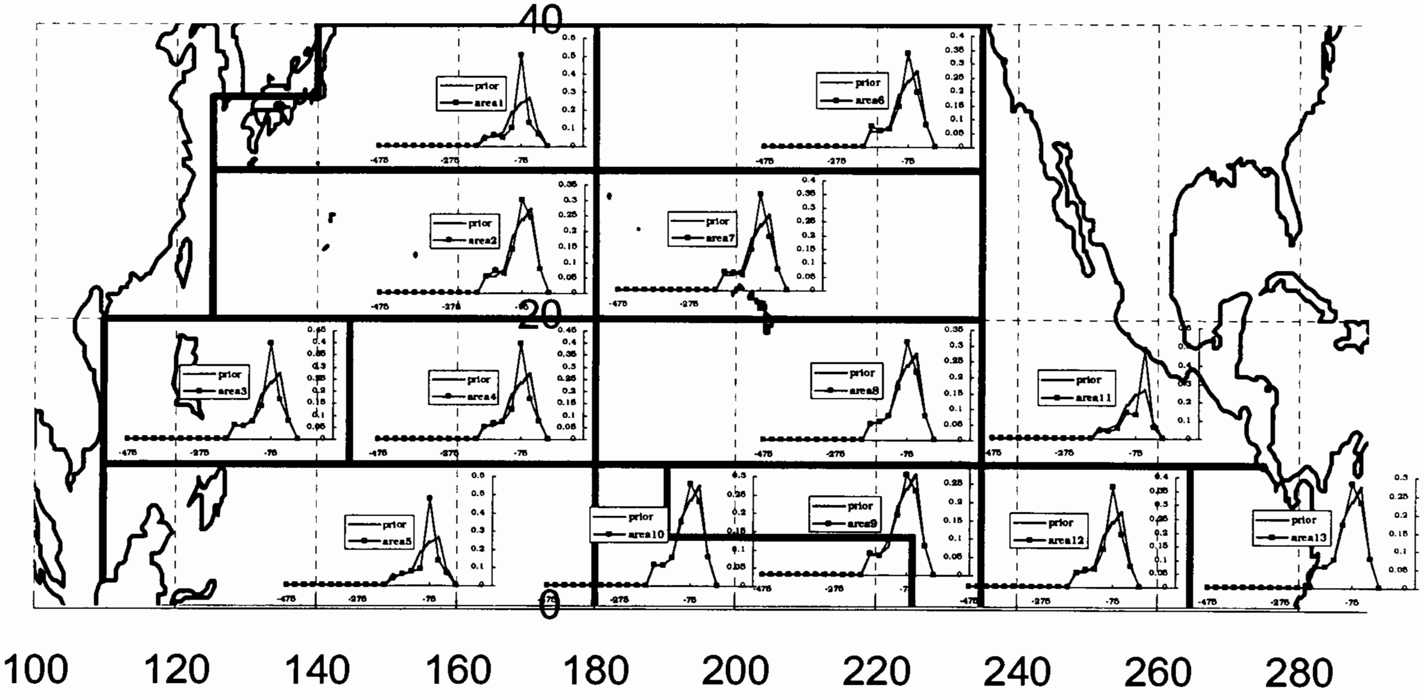

Fig. 11 Estimated and prior distribution of habitat preference on area separation I. Absolute depth is used as habitat preference.

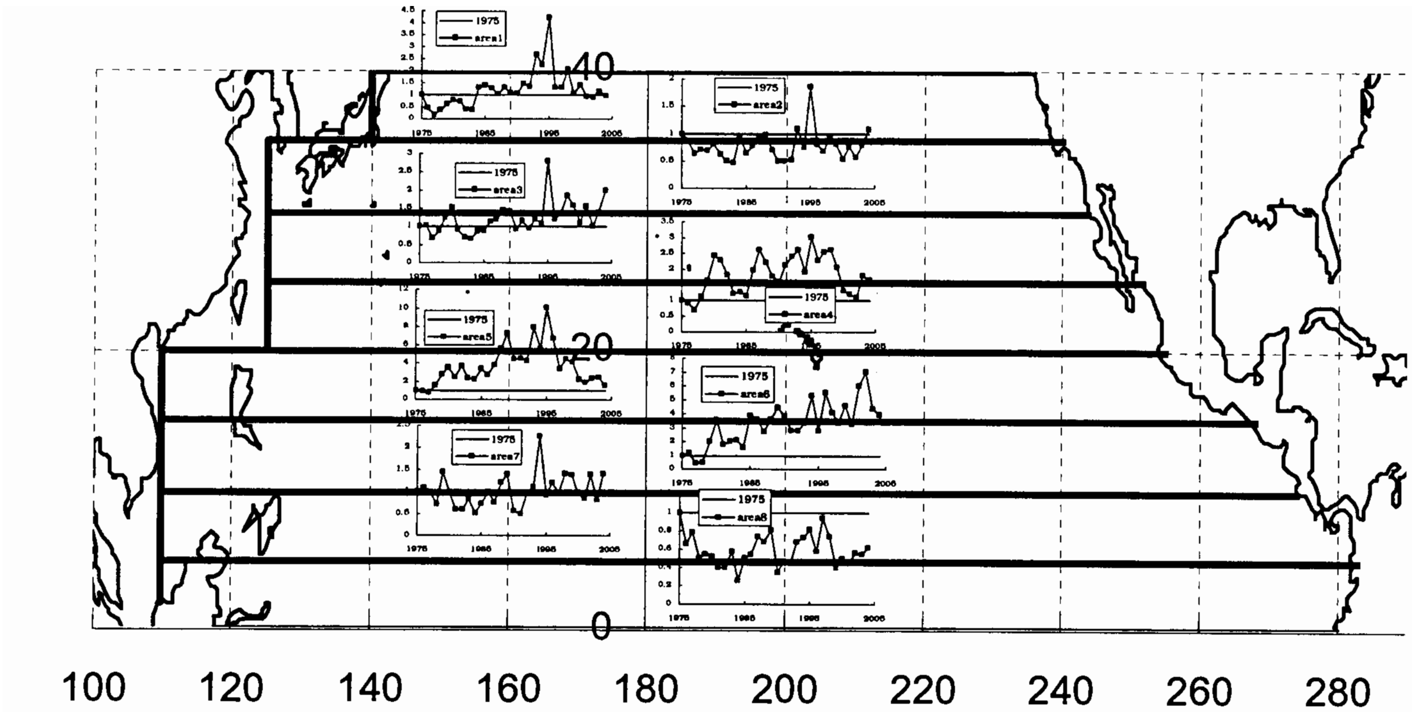

Fig. 12 Annual trend of sCPUE on area separation II. Absolute depth is used as habitat preference.

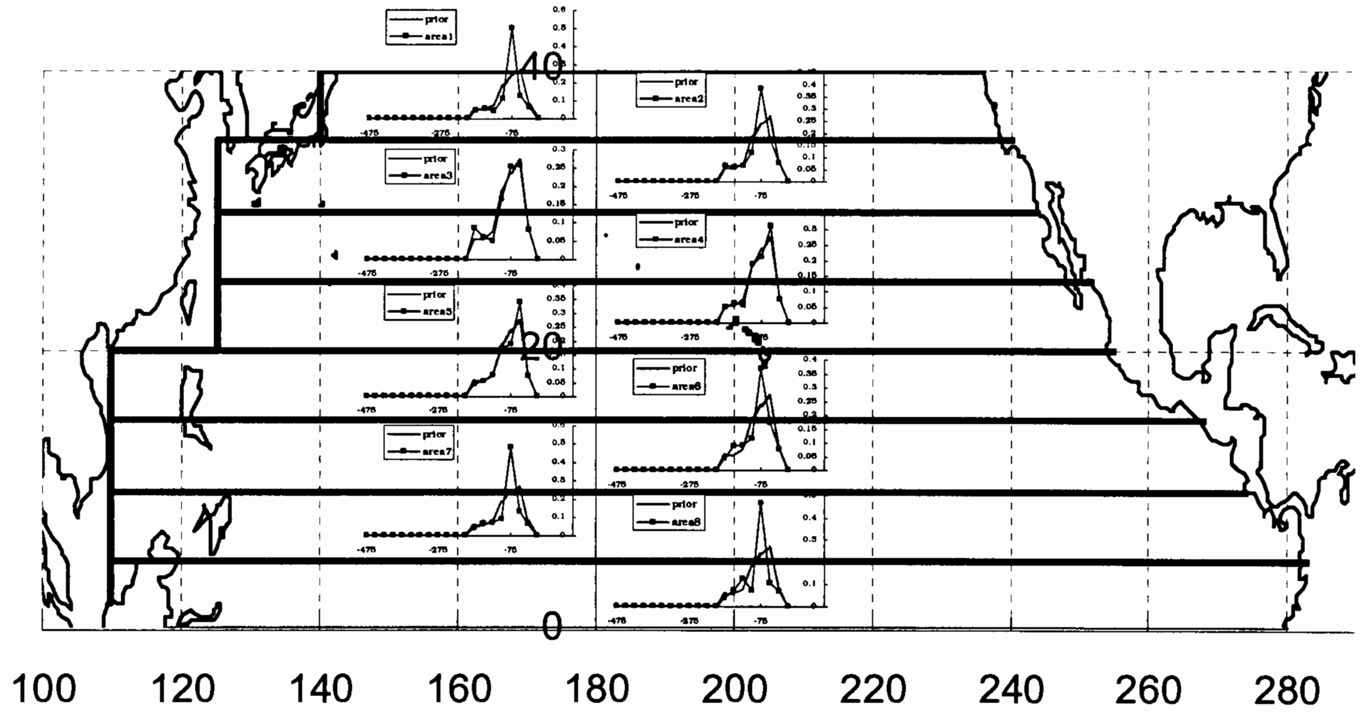

Fig. 13 Estimated and prior distribution of habitat preference on area separation II. Absolute depth is used as habitat preference.

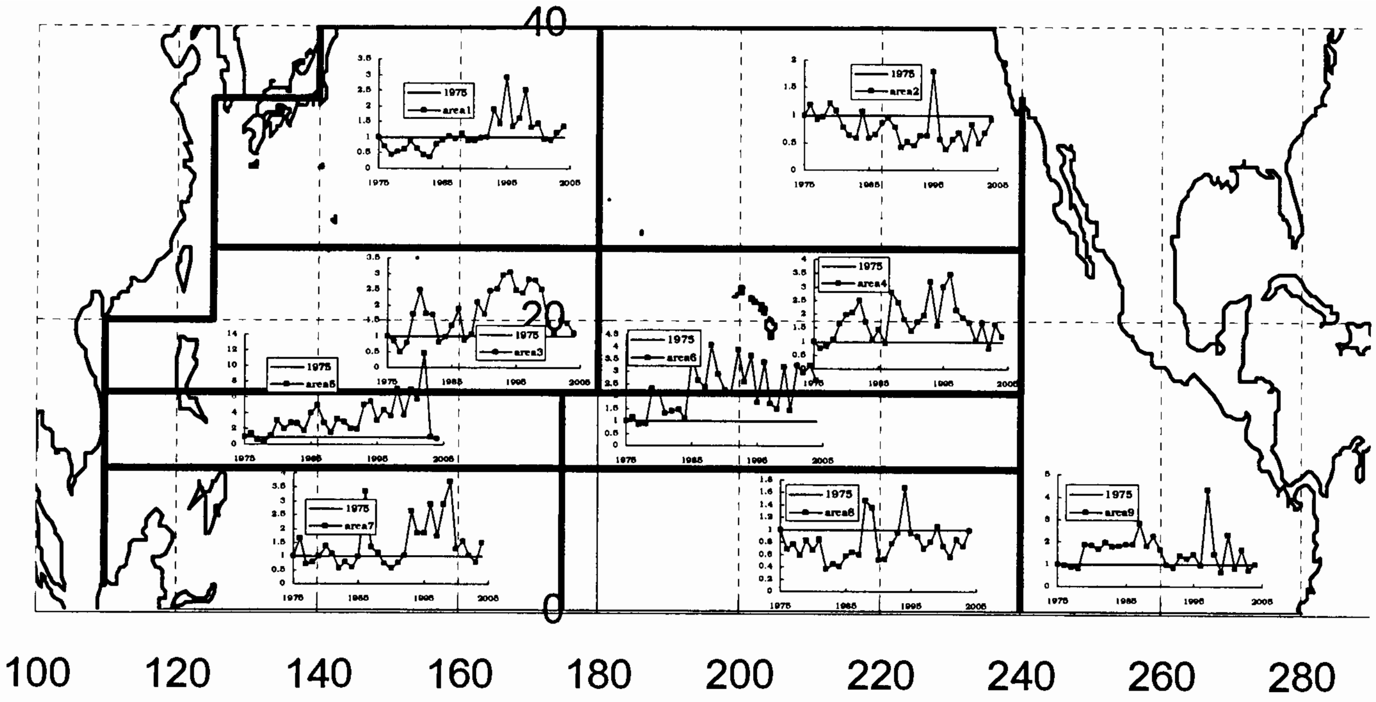

Fig. 14 Annual trend of sCPUE on area separation III. Absolute depth is used as habitat preference.

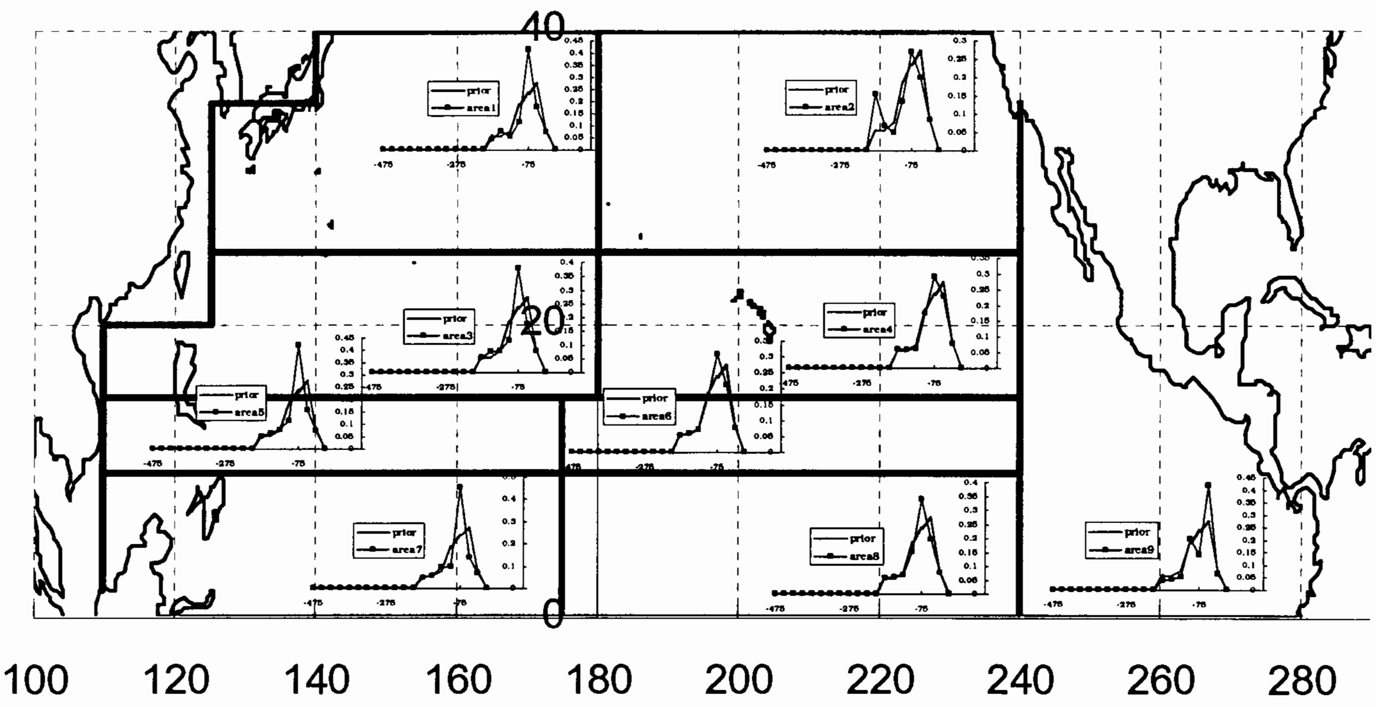

Fig. 15 Estimated and prior distribution of habitat preference on area separation III. Absolute depth is used as habitat preference.

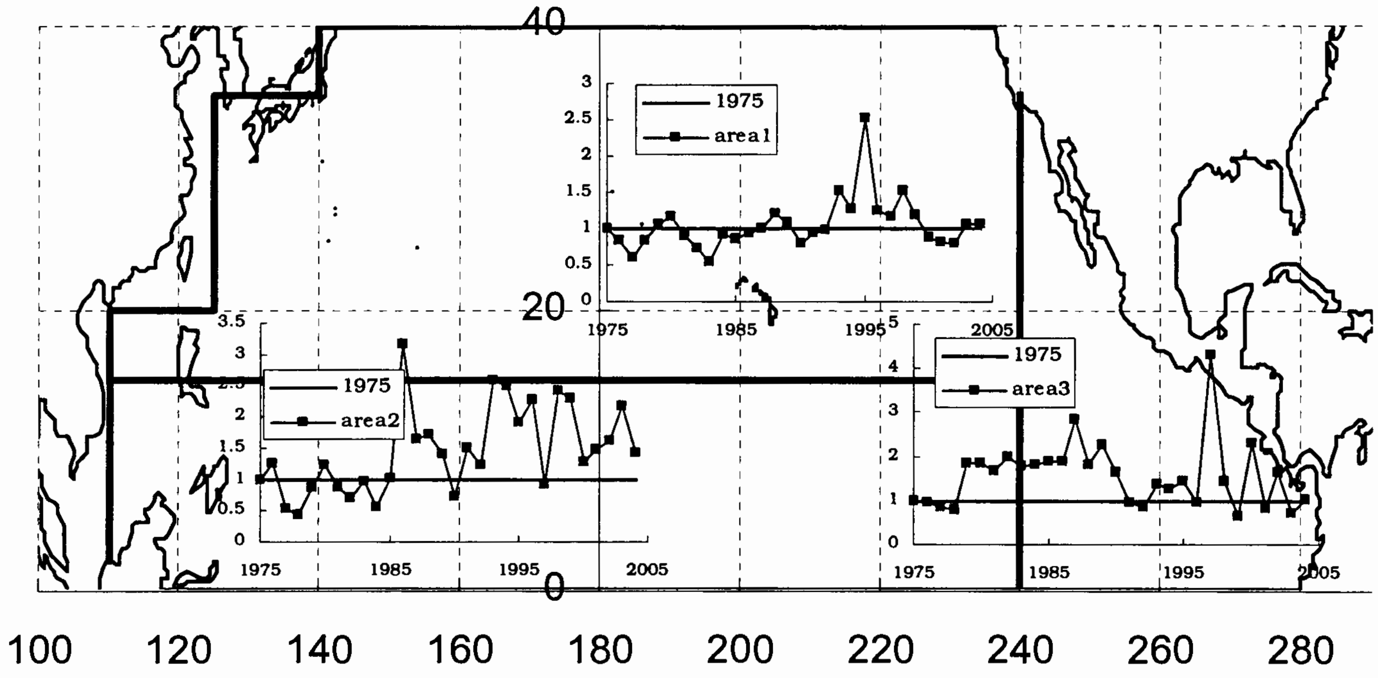

Fig. 16 Annual trend of sCPUE on area separation IV. Absolute depth is used as habitat preference.

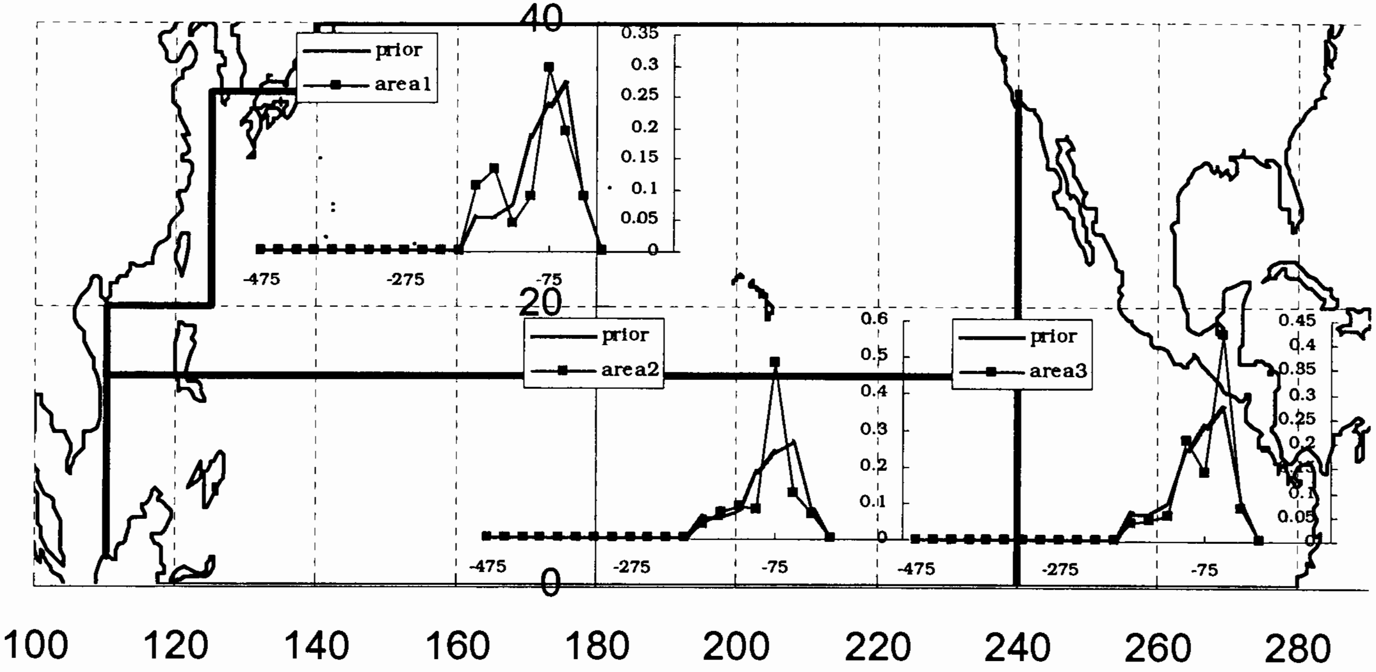

Fig. 17 Estimated and prior distribution of habitat preference on area separation IV. Absolute depth is used as habitat preference.

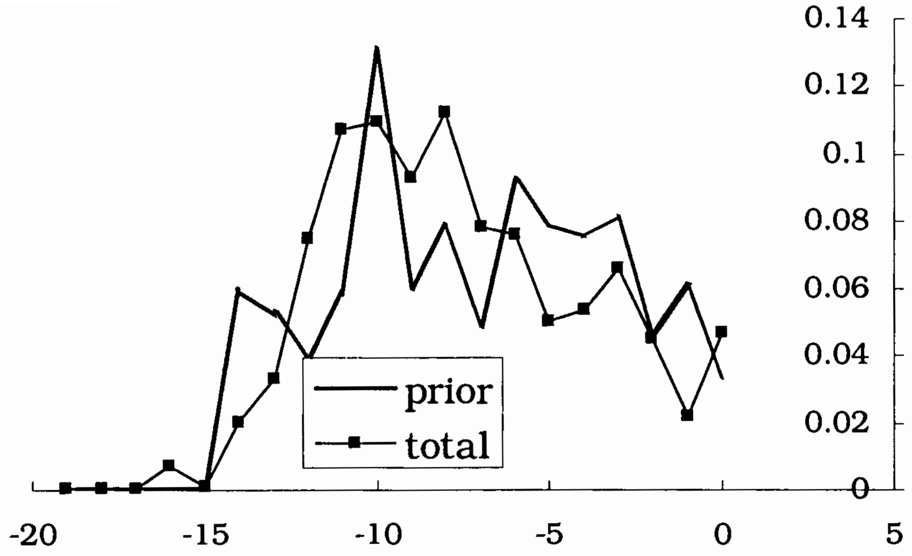

Fig. 18 Estimated and prior distribution of habitat preference on each relative temperature without any area-separation (c.e. using all data together).

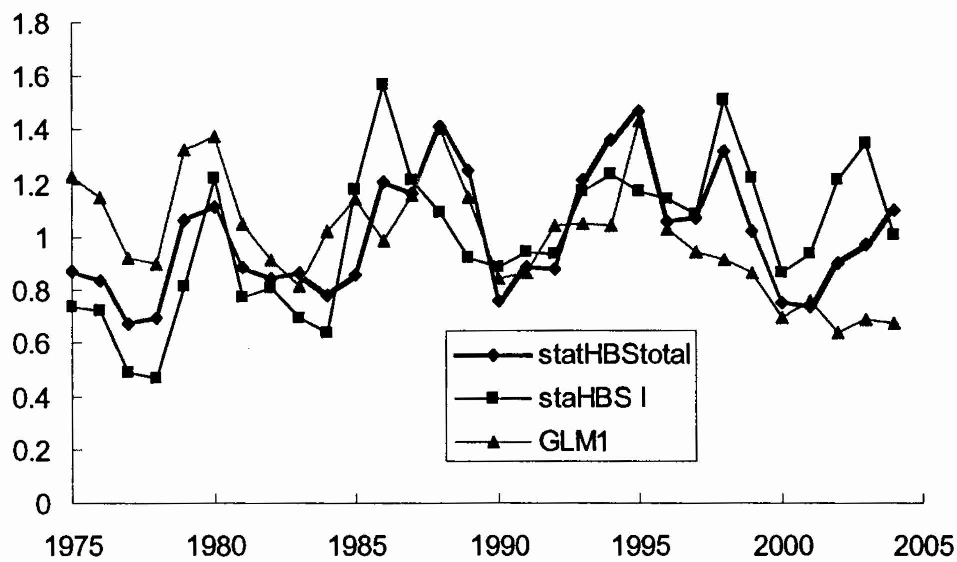

Fig. 19 Annual trend of sCPUE, statHBStotal is using all data together, statHBS I calculate annual trend separately followed by area-separation I, weighted by area dimension and summed up. GLM1 is calculated by using GLM with same area-separation. Relative temperature is used as habitat preference.

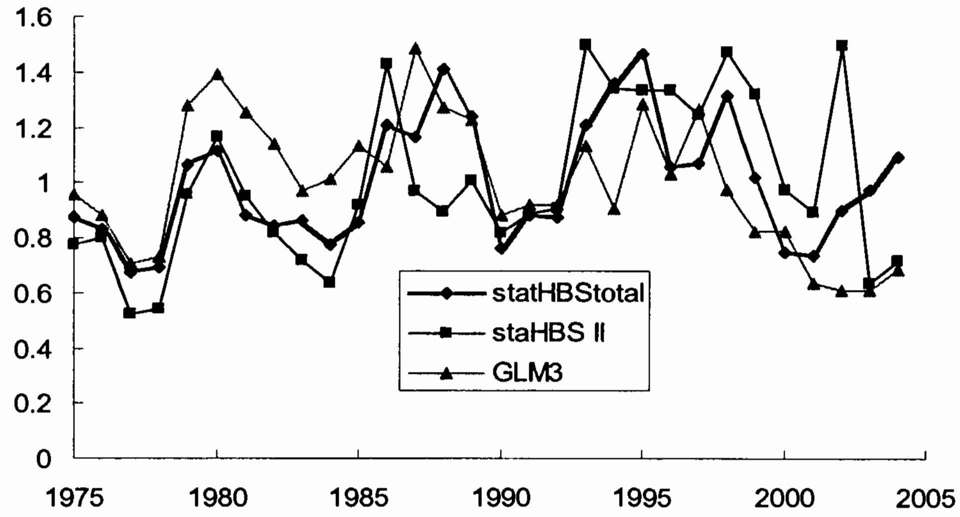

Fig. 20 Annual trend of sCPUE, statHBStotal is using all data together, statHBS II calculate annual trend separately followed by area-separation II, weighted by area dimension and summed up. GLM3 is calculated by using GLM with same area-separation. Relative temperature is used as habitat preference

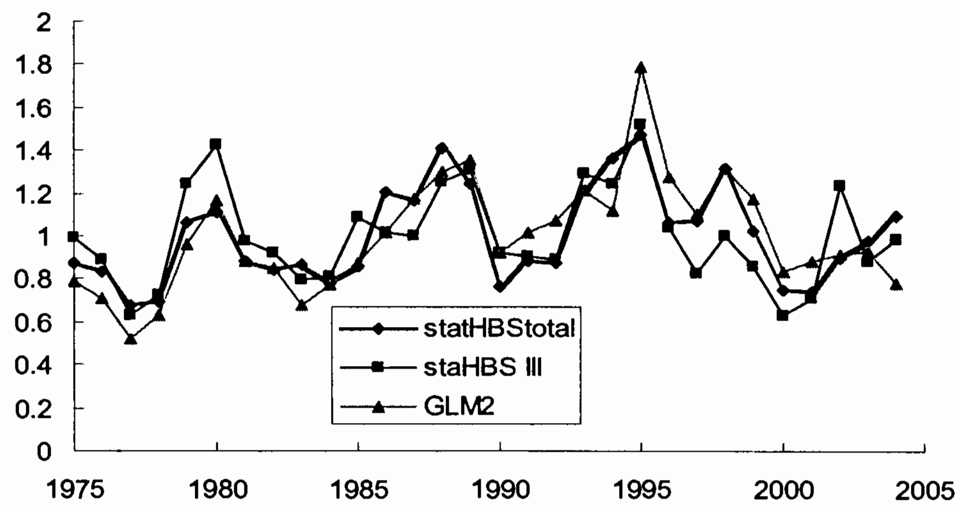

Fig. 21 Annual trend of sCPUE, statHBStotal is using all data together, statHBS III calculate annual trend separately followed by area-separation III, weighted by area dimension and summed up. GLM2 is calculated by using GLM with same area-separation. Relative temperature is used as habitat preference.

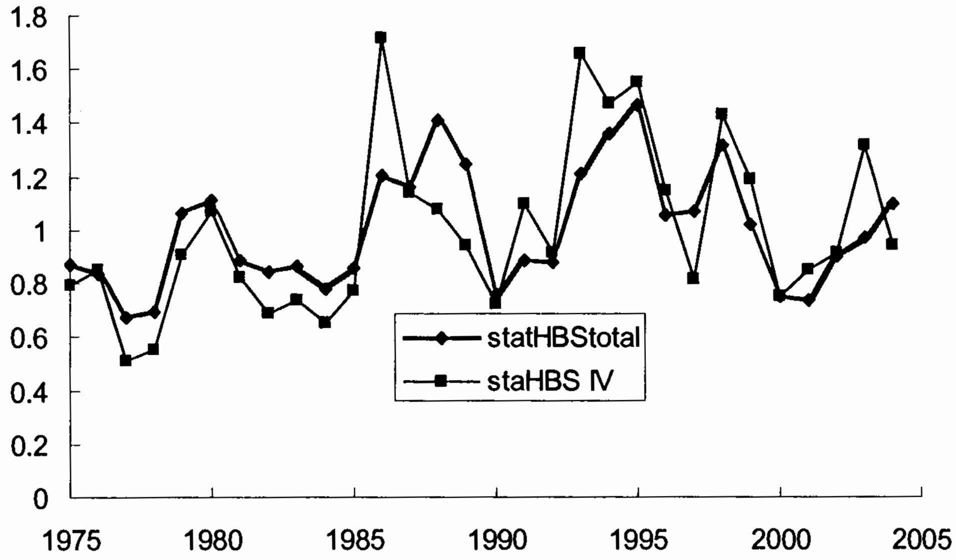

Fig. 22 Annual trend of sCPUE, statHBStotal is using all data together, statHBS IV calculate annual trend separately followed by area-separation IV, weighted by area dimension and summed up. Relative temperature is used as habitat preference.

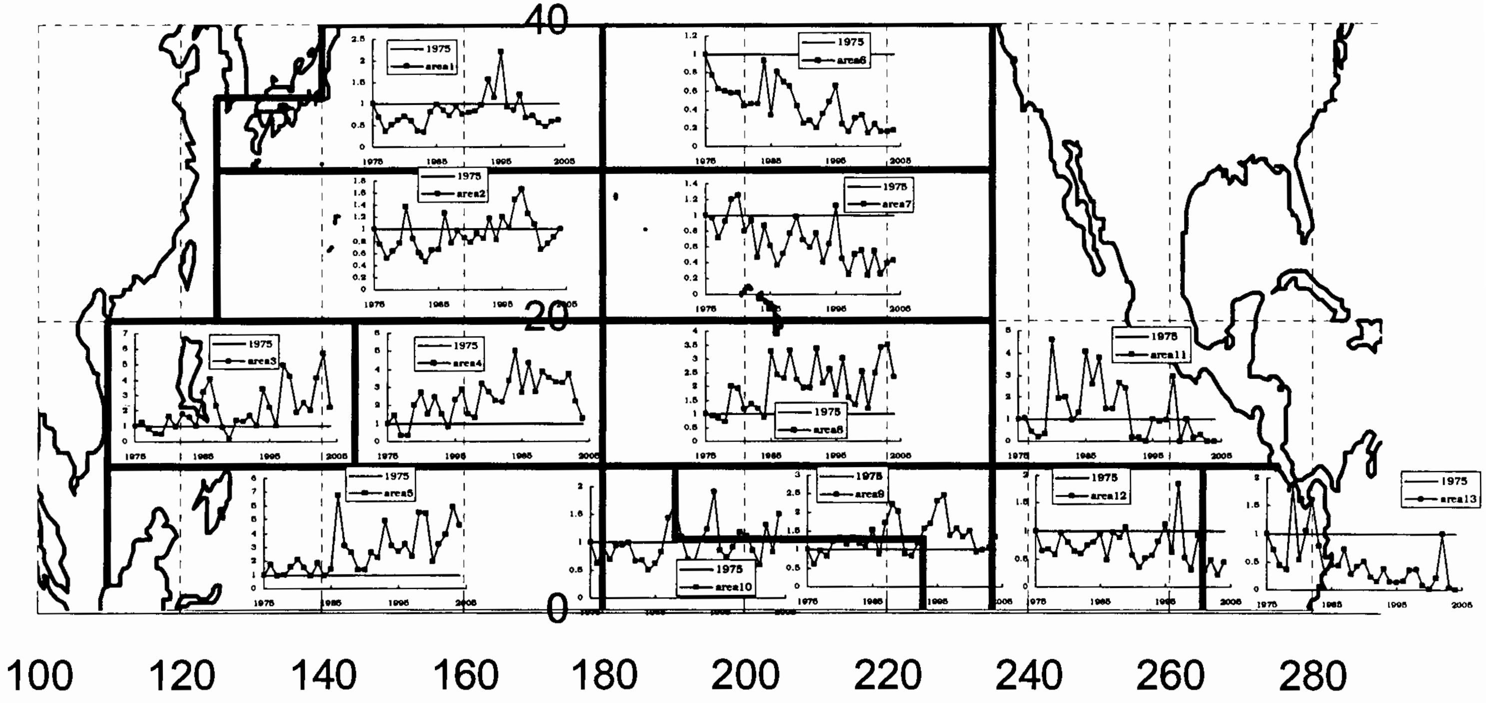

Fig. 23 Annual trend of sCPUE on area separation I. Relative temperature is used as habitat preference.

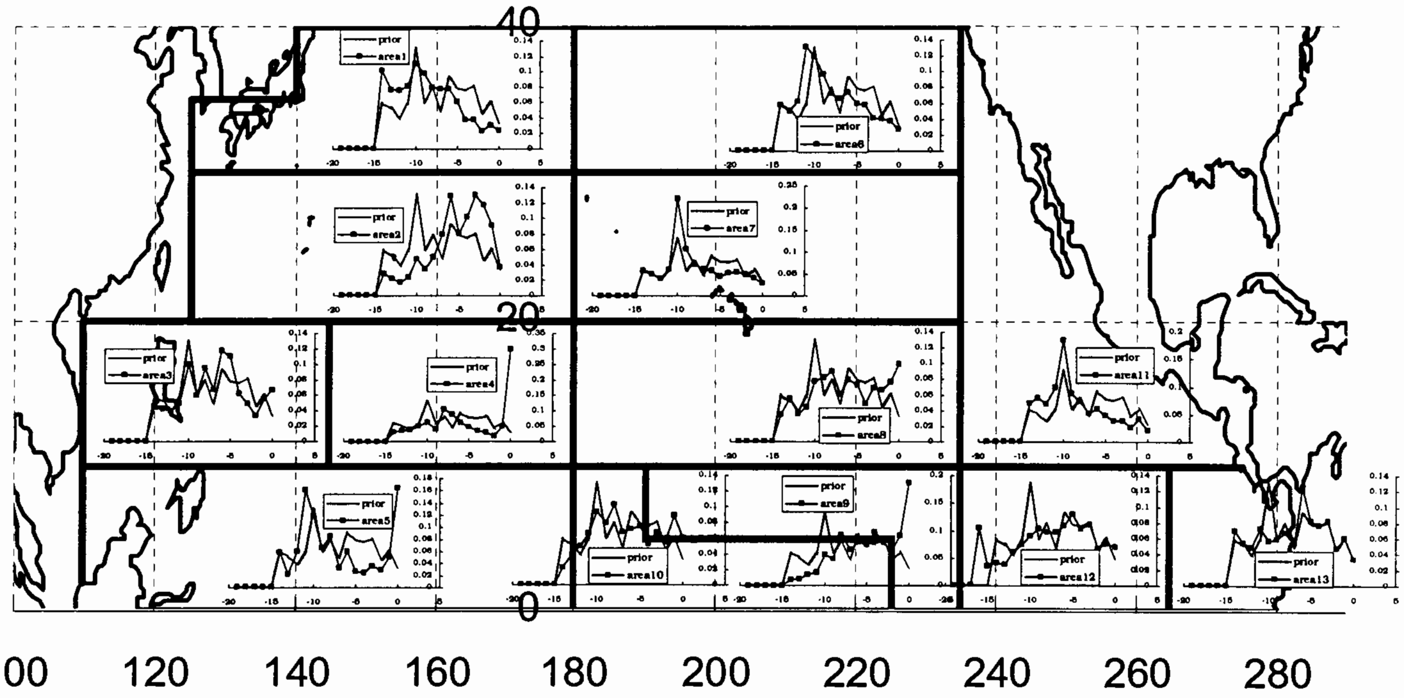

Fig. 24 Estimated and prior distribution of habitat preference on area separation I. Relative temperature is used as habitat preference.

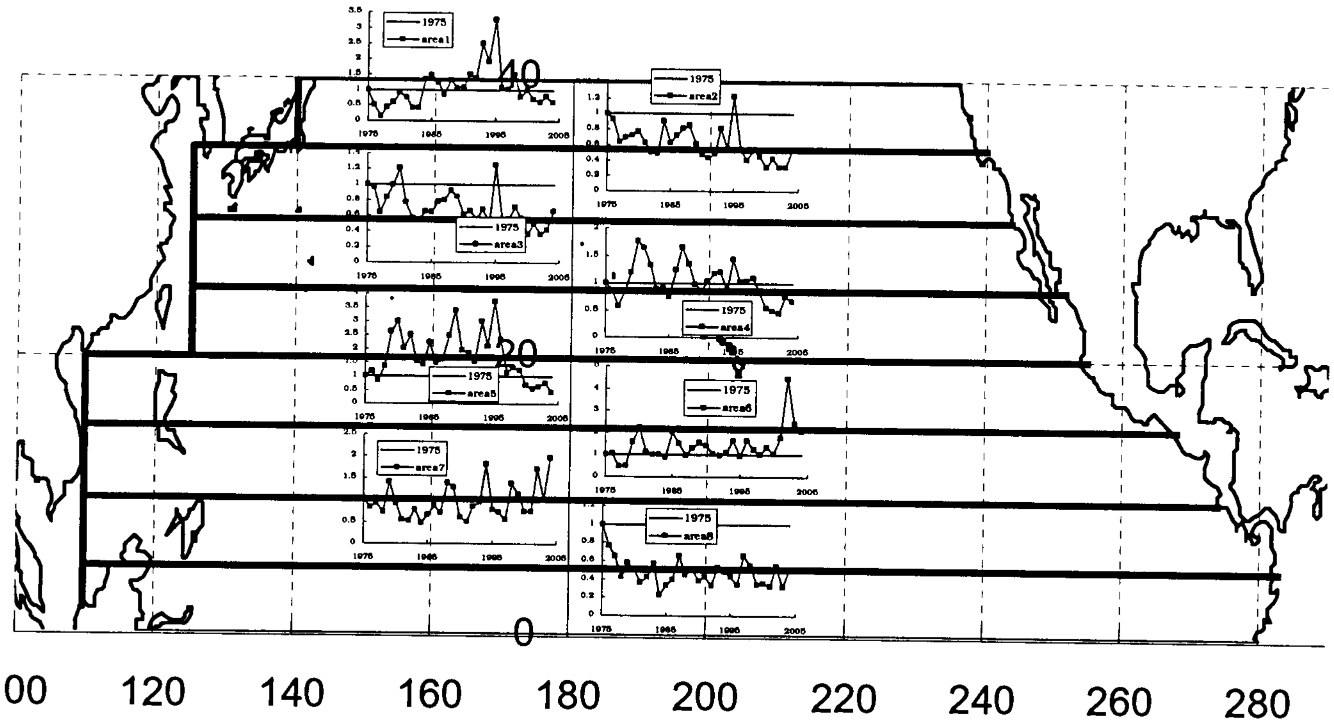

Fig. 25 Annual trend of sCPUE on area separation II. Relative temperature is used as habitat preference.

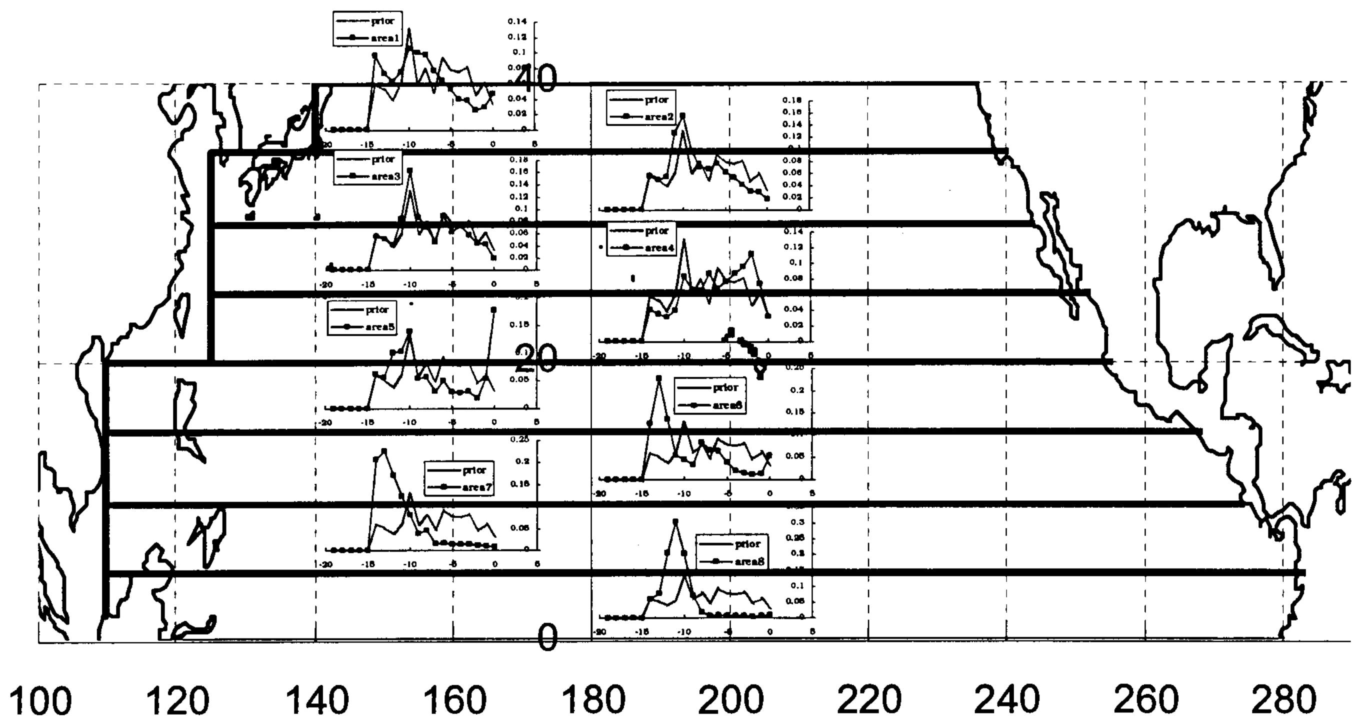

Fig. 26 Estimated and prior distribution of habitat preference on area separation II. Relative temperature is used as habitat preference.

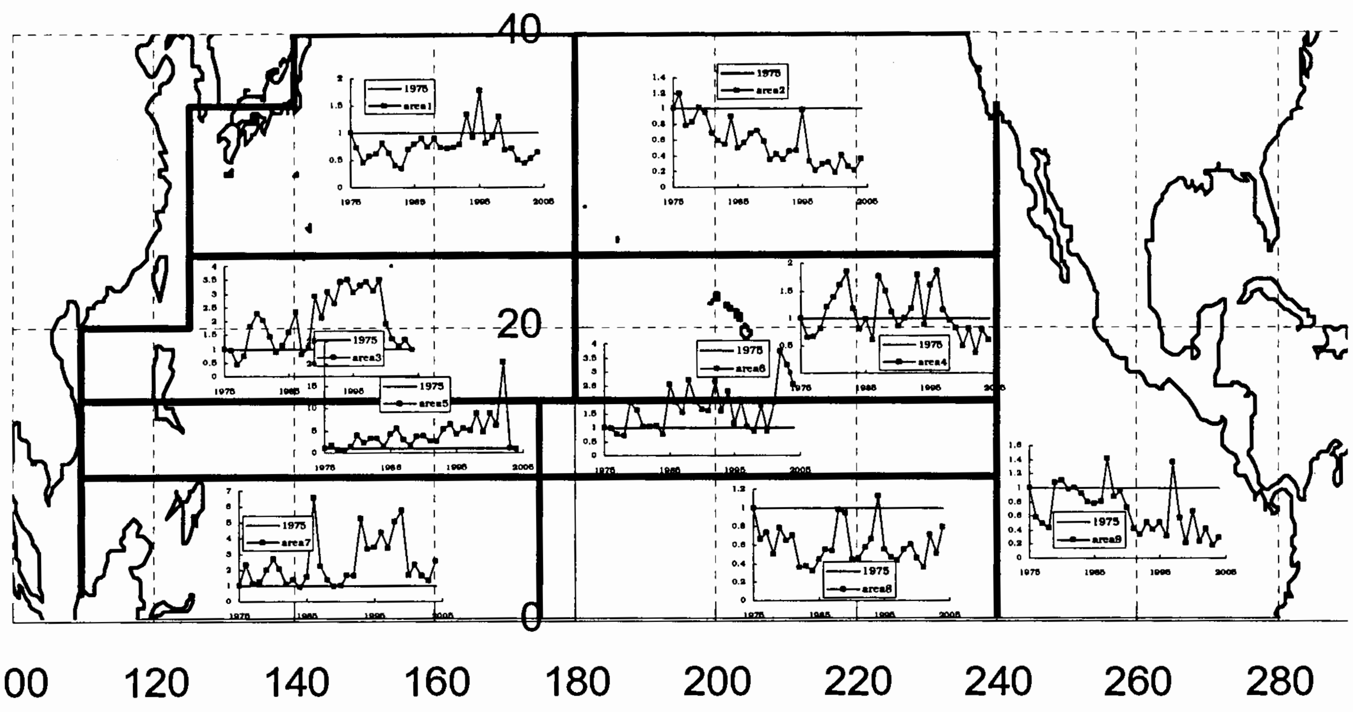

Fig. 27Annual trend of sCPUE on area separation III. Relative temperature is used as habitat preference.

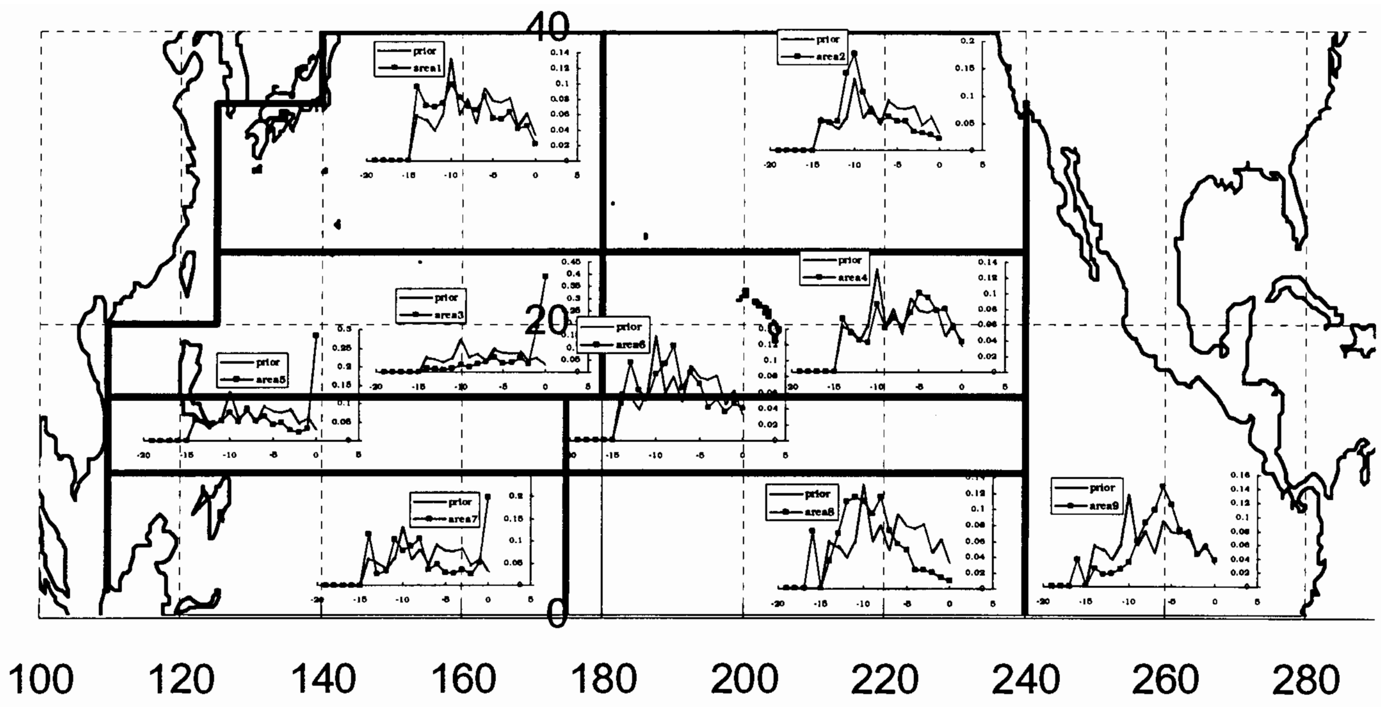

Fig. 28 Estimated and prior distribution of habitat preference on area separation III. Relative temperature is used as habitat preference.

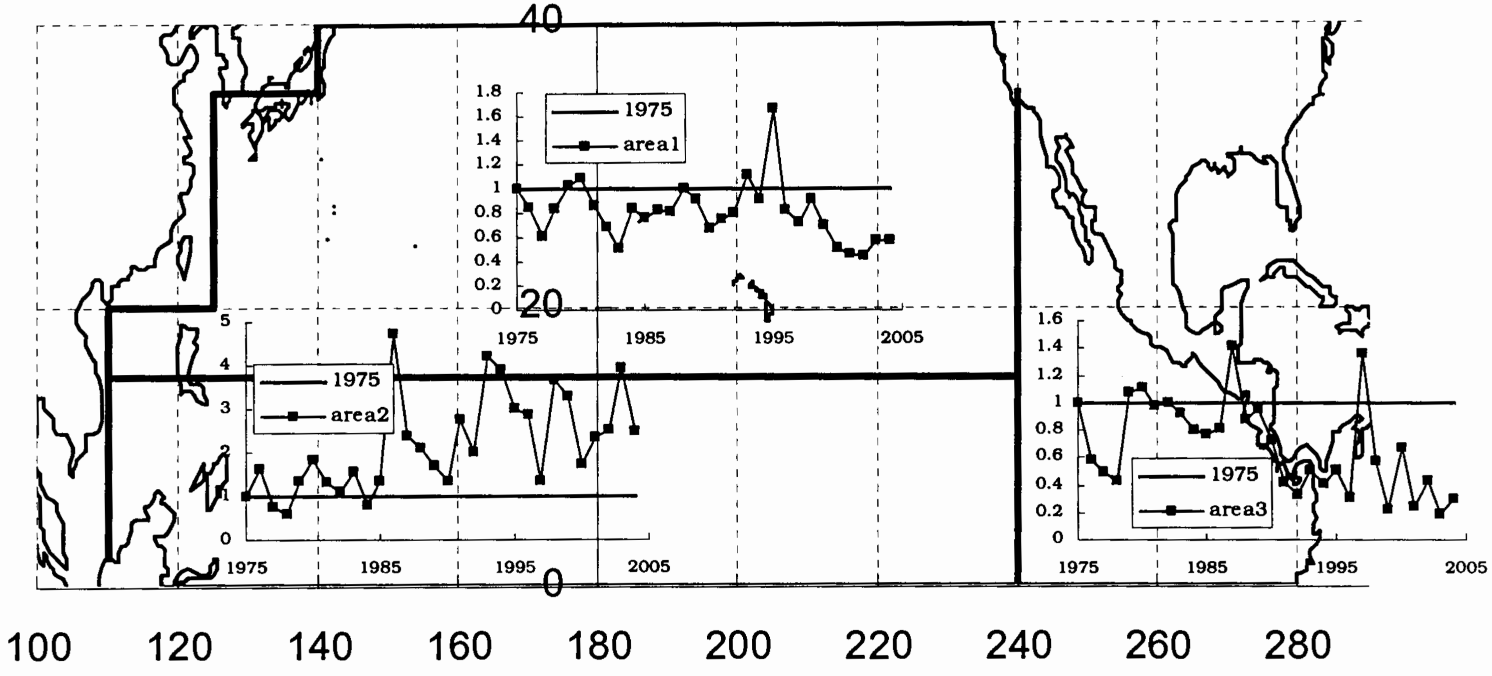

Fig. 29 Annual trend of sCPUE on area separation IV. Relative temperature is used as habitat preference.

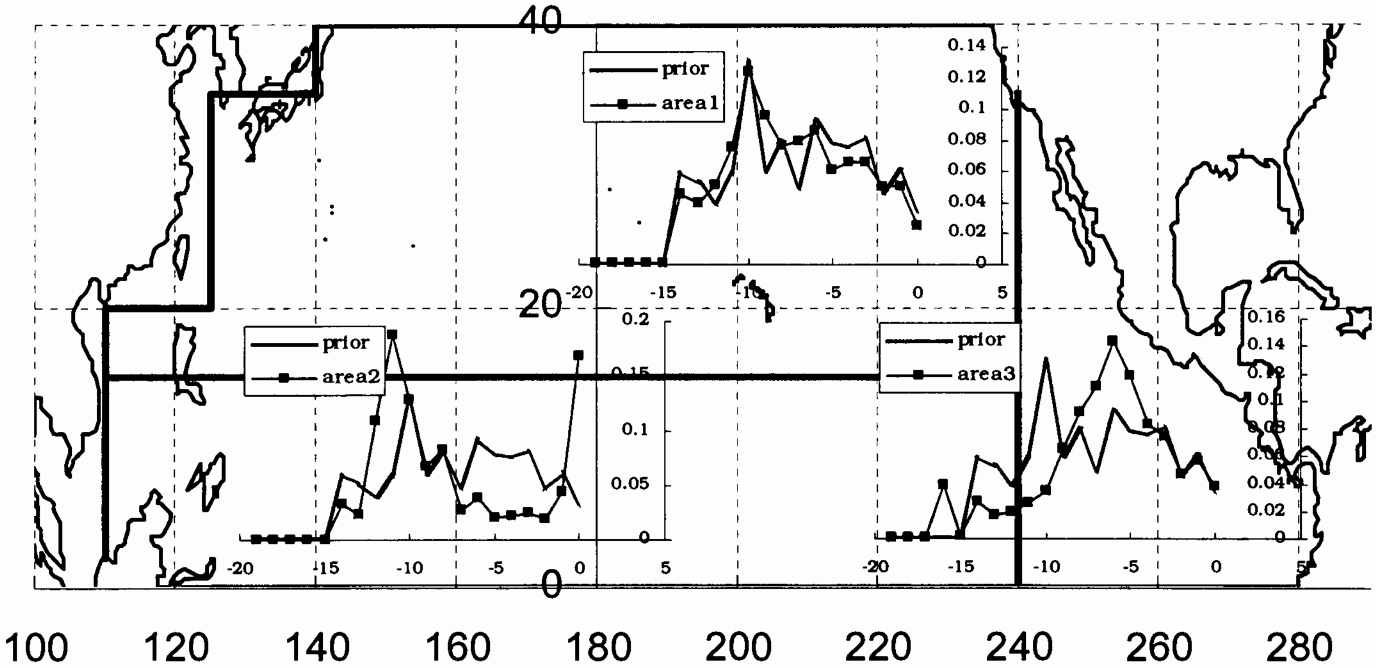

Fig. 30 Estimated and prior distribution of habitat preference on area separation IV. Relative temperature is used as habitat preference.

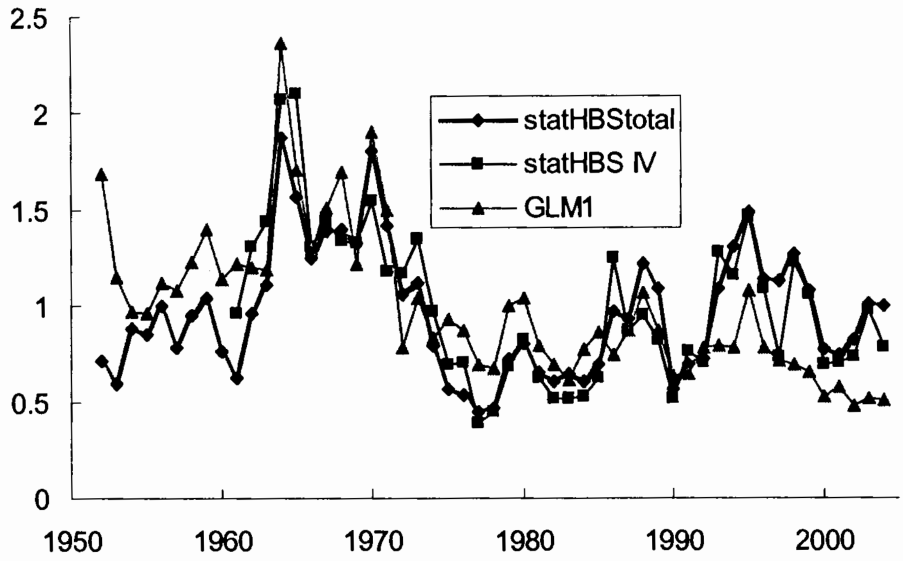

Fig. 31 Annual trend of sCPUE using absolute depth as habitat preference. From 1952 to 1961, statHBS IV has some area without enough data, so there is no result from 1952 to 1960.

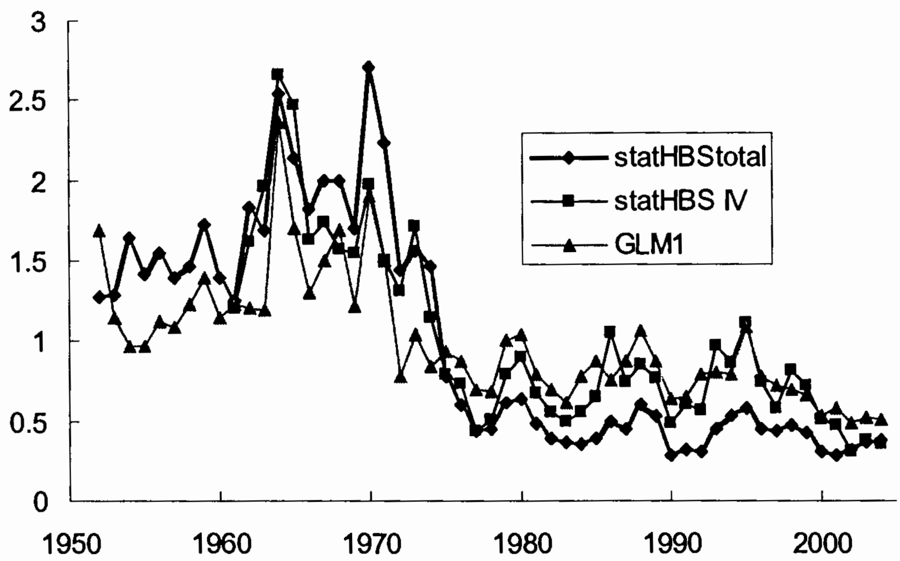

Fig. 32 Annual trend of sCPUE using relative temperature as habitat preference. From 1952 to 1961, statHBS IV has some area without enough data, so there is no result from 1952 to 1960.

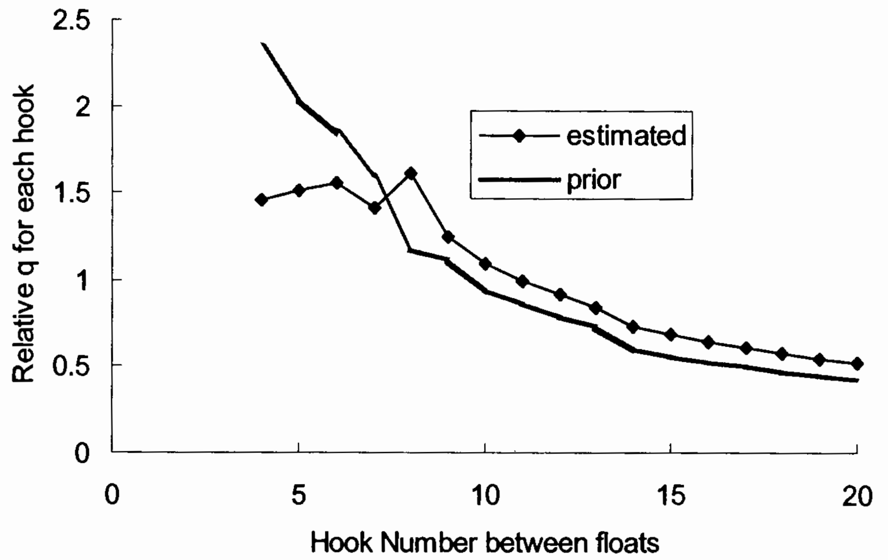

Fig. 33 Relative gear performance for each hook by NHF which estimated by using absolute depth.