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Abstract

We figured out the sensitivity of spatial and annual effect of annual trend of standardized catch per unit effort (sCPUE) and habitat preference. We got 3 results. 1) difference of starting year of data-set does not affect to annual trend of sCPUE but habitat preference, 2) prior distribution of habitat preference does not affect both and 3) spatial difference affect both, especially IDL is the turning point of the sCPUE's annual trend. We suggest that we need to make clear how to treat zero catch (0-catch), what prior habitat preference information is the best for striped marlin and how categorize the data set by fishing gears. These should be additional works.

Introduction

Catch per unit effort (CPUE) is the mostly commonly used abundance index, but the relationship between catch and effort may differ when environmental factors such as depth, salinity and/or temperature determine the fishery target species niche but not the distribution of fishing operations. Under such conditions, nominal CPUE will not reflect abundance 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 to standardize CPUE using habitat information and statistical methods and to show which standardization parameters are key to estimating annual trends in abundance.

Data sets

Data from the Japanese longline fishery from 1975 to 2003 were aggregated by month, 5-degree square and the number of hooks between floats (NHF).

We used seawater temperature relative to sea surface temperature (SST) as habitat information. We obtained 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 limited the timeframe to between 1975 and 2001 because there are no NHF data prior to 1975 and there are no environmental data after 2001.

Our target area for this study is the North Pacific Ocean as shown by the gray line in Fig. 1.

We used only sets which caught at least one striped marlin and eliminated all sets with 0-catch. .

Vertical distribution probabilities of striped marlin estimated using data collected by past telemetry studies (Hinton, M., personal comm.) were used as prior probability distributions and checked for sensitivity.

The gear configuration is referred to as regular longline gear (Yoshiwara 1951 and Suzuki et al., 1977).

The data were divided by year or by area in order to test the sensitivity of the results in each scenario.

Method

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

We chose the annual trend of standardized CPUE and a habitat preference probability as the estimated parameters. sCPUE in 1975 is standardized as 1 and the values in other years show as relative number from it.

We chose 3 scenarios based on various subsets of the data to be analyzed. Each scenario is described below.

Scenario 1. All data with 4 types of prior information on habitat preference (Fig. 2). First distribution (s1) follows observed habitat preference, s2 is the case which has peak between -2 and -4 degree, s3 is the case which higher degree's preference is high and lower one is low and s4 is uniform distribution.

Scenario 2. Analysis of spatial effects by separating the data by 180 degree longitude and 20 degree north. To analyze more detail, we estimate the parameters in each 10 degree of longitude, also.

Scenario 3. Analysis of time series effects by altering the starting year of input data one year at a time.

Result and Discussion

Scenario 1. Annual sCPUE shows some variation and there is slight downward trend (Fig. 3). We calculated the difference between the annual trends of sCPUE using statHBS, GLM and habitat models (Fig. 3). The range of variation differs greatly between models, with GLM and habitat models showing a wider range of annual values and statHBS showing a narrower range. But the basic trend, i.e., increase until the middle of 1990s and decrease thereafter and the timing of the change in trend, is same.

The priors on habitat preference do not affect the results in any way (Fig. 3). There are three possible reasons for this. First, habitat preference does not actually affect sCPUE. This means that the trend in sCPUE can be sufficiently explained by the annual change in the spatial distribution of effort. Second, habitat preference does not cover longline hook's vertical coverage as well. In this study minimum relative temperature set -8 degree, but longline hook can stay lower degree. Third, relative temperature may not be appropriate as the main discriminant of habitat preference. Depth from surface might be better discriminant of habitat preference. This should be the subject of additional study.

Scenario 2. The annual trend in sCPUE does not show any difference when the data set is split between north and south but there are obvious differences between east and west (Fig. 4). So we estimated the annual trend of sCPUE for every 10 degree band in longitude (Fig. 5) and the results showed that the International Date Line (IDL; 180 degrees) is the turning point for annual trend. West of the IDL, the annual trend is upward or stable, but east from that point, it is downward

(Fig. 5). This suggests that there may be different population dynamics in the eastern and western North Pacific Ocean but no differences between north and south. On estimated habitat preference, spatial difference affect between east and west but almost not affect between north and south (Fig. 4).

Scenario 3. There is not almost no effect due to changing the starting year of the data set when estimating the annual trend of sCPUE(Fig. 6). But on estimation of habitat preference around 1990 there is an obvious change and they are estimated differently between data set which start either before or after 1990. It has some kind of syntony with the changing year of fishing gear (Sawadaishi J., personal comm.).

In this study we assumed there are no annual and spatial changes in habitat preference but these results indicate we should divide annual and/or spatial habitat preference at least some category.

We did not include any of the 0-catch data for estimation because striped marlin is not the main target of the Japanese longline fishery. Because if 0-catch is changing annually, it will affect strongly but we assume the change of frequency is small.

Additional work is required to check whether there has been an historical change of effort distribution in the areas where we observed 0-catch of striped marlin. We checked the frequency distribution of 0-catch from 1975 to 1993 (Fig. 7). We cannot find any annual change on that frequency so 0-catch may not affect to estimation of annual sCPUE trend nor habitat preference.

A 0-catch could mean one of three situations: 1) there are actually no fish in that area; 2) there exists some fish, but due to lack of effort or by chance fishermen do not catch striped marlin there or 3) there was catch but it is not recorded. If, in the area of reported 0-catch, there has been no historical change of effort, there would be no effect on the estimated parameters. But if there has been some historical change in effort, it may have the effect of altering estimated parameters.

Fortunately, even if striped marlin is not main target but there are some markets, historically, so probably fishermen probably retain that specie. So we may not need to worry about 3) no recording problem.

For 1) and 2), we cannot say exactly yet, but at least there is no area where 0-catch continue between 1975 and 1993 (Fig. 8). Almost areas, over half areas, have some catch more than 18 years.

We need to check whether there is a change of gear frequency, e.g. NHF, in the area which has 0-catch, a change of annual pattern of 0-catch, e.g. if 5 0-catchs occurred in one area, whether it occurred continuously or on-and-off, what is monthly annually pattern, and/or whether these patterns are changed by each area. We need to try some models for the areas without any effort. These all should be additional work.

We started the estimation of sCPUE from 1975 because there is no information on NHF prior to this date, but we can assume all NHF were 5 until 1975 (Yokawa 2004). If we then use the estimated habitat preference from this study as the true habitat preference and estimate the sCPUE from the early 1950s it may be helpful in understanding the annual trend in sCPUE.

Environmental data may not have enough vertical resolution because the unit form habitat preference is about 10m and we don't know the exact unit of vertical resolution within the SODA datasets, clearly. This is also a topic for future investigation.

One of the most difficult aspects of estimating an abundance index for striped marlin from commercial catch data arises from the fact that striped marlin is not a main target species for many vessels. Therefore, even if we standardize the effort using habitat information, it may not reflect true fishery intensity on that species. If we want to estimate stock abundance, we may need to do conduct survey operations targeting striped marlin for tagging or we need to focus our analysis on data from the vessels which specifically target striped marlin in order to estimate fishery availability directly.

As a first step, we should categorize fishing gear and focus our analysis on data from vessels targeting striped marlin. In the future, we need to use such information as priors when standardize CPUE as the index of abundance.

References

Bigelow, K. A., A. D. Langley and T. Patterson, (2004) Relative abundance indices of the Japanese longline fishery for bigeye and yellowfin tuna in the western and central Pacific Ocean. SCTB17 WP SA-7.

Carton, J. A., G. Chepurin, X. Cao, and B. Giese, (2000a) A Simple Ocean Data Assimilation Analysis of the Global Upper Ocean 1950-95. Part I: Methodology. J. Phys. Oceanogr., 30, 2, 294-309.

Carton, J. A., G. Chepurin, and X. Cao (2000b), A simple ocean data assimilation analysis of the global upper ocean 1950 – 1995 part II: Results, J. Phys. Oceanogr., 30, 311– 326.

Hinton, M. and H. Nakano. (1996), Standardizing catch and effort statistics using physiological, ecological, or behavioral constraints and environmental data, with an application to blue marlin (*Makaira nigricans*) catch and effort data from Japanese longline fisheries in the Pacific. Bull. Int. Am. Trop. Tuna Comm. 21(4): 171−200.

Suzuki, Z., Y. Warashina and M. Kishida. (1977), The comparison of catches by regular and deep tuna longline gears in the western and central equatorial Pacific. Bull. Far Seas Fish. Res. Lab., 15: 51-89

Yoshihara, T. (1951), Distribution of catches of Tuna Longline - II. Bull. of the Japanese Soc. of Sci. Fish., 16: 370-374.

Yokawa, K. (2004), Standardizations of CPUE of striped marlin caught by Japanese offshore and distant water longliners in the north west and central Pacific. ISC/04/0MARLIN-WG/02.

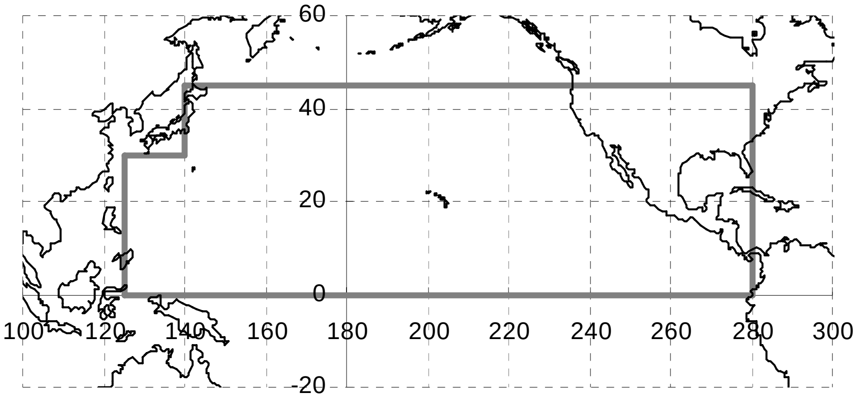


Fig. 1
Target area for this study.

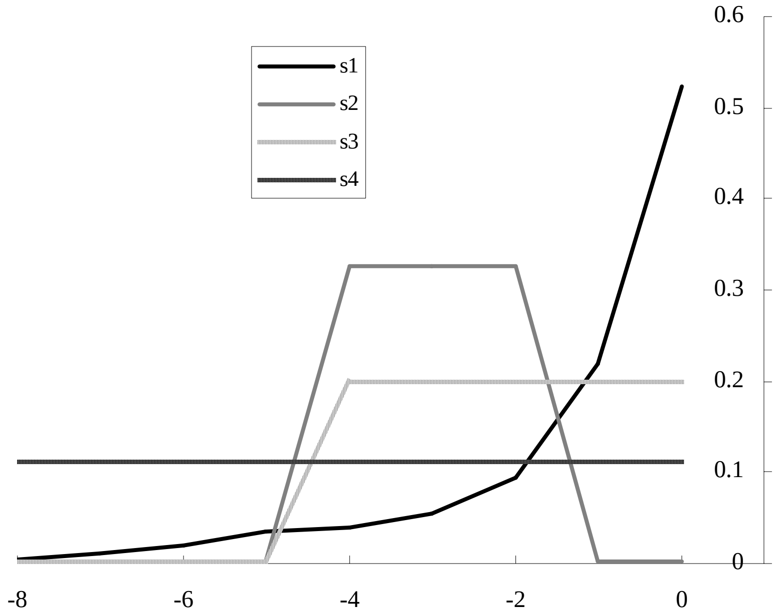


Fig. 2 Prior distributions for habitat preference.
s1 follows observed habitat preference, s2 is the case which there is a peak in the mid-range temperatures, s3 is the case in which the probability is higher at higher temperatures and s4 is the case which the probability is a uniform.

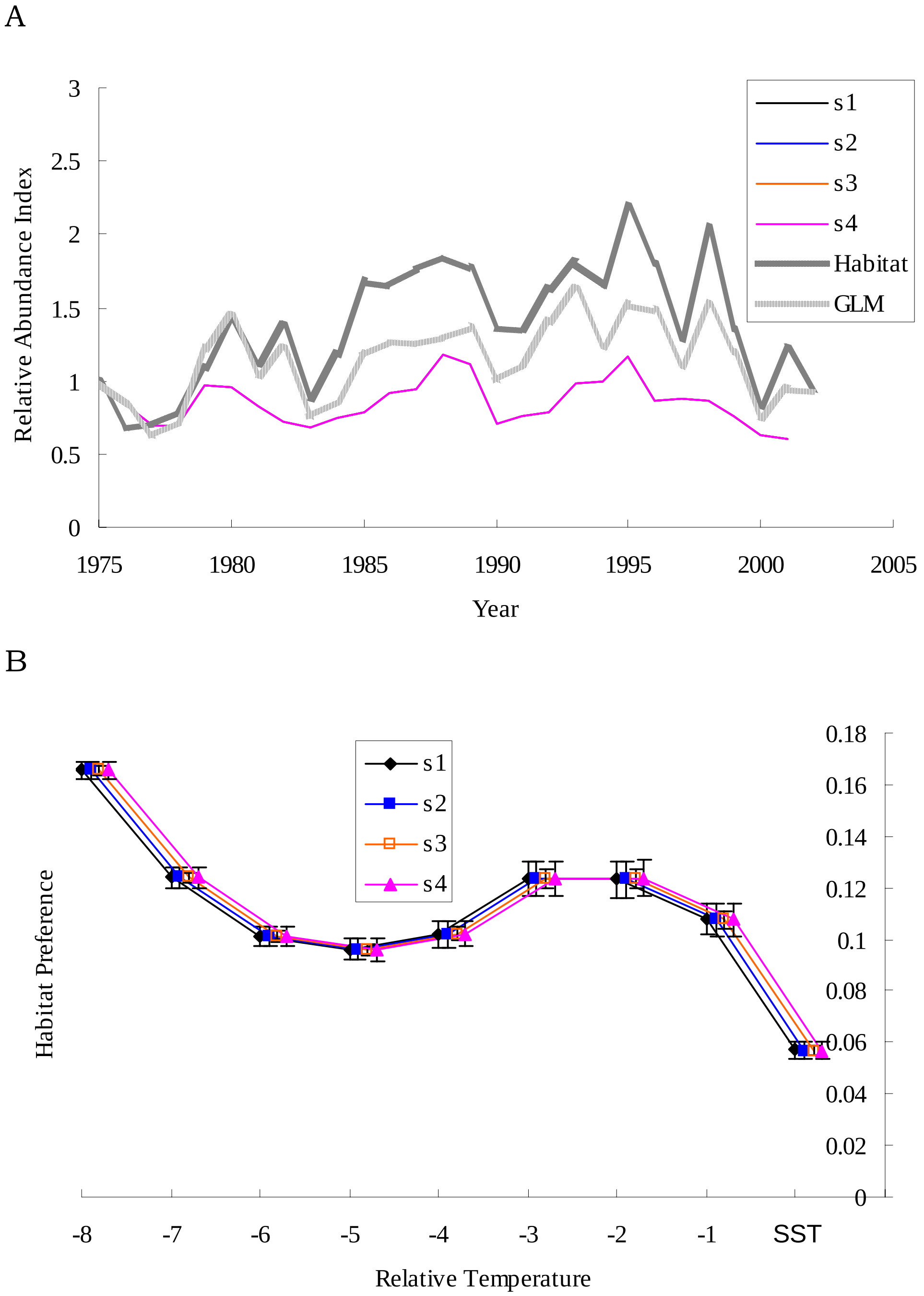
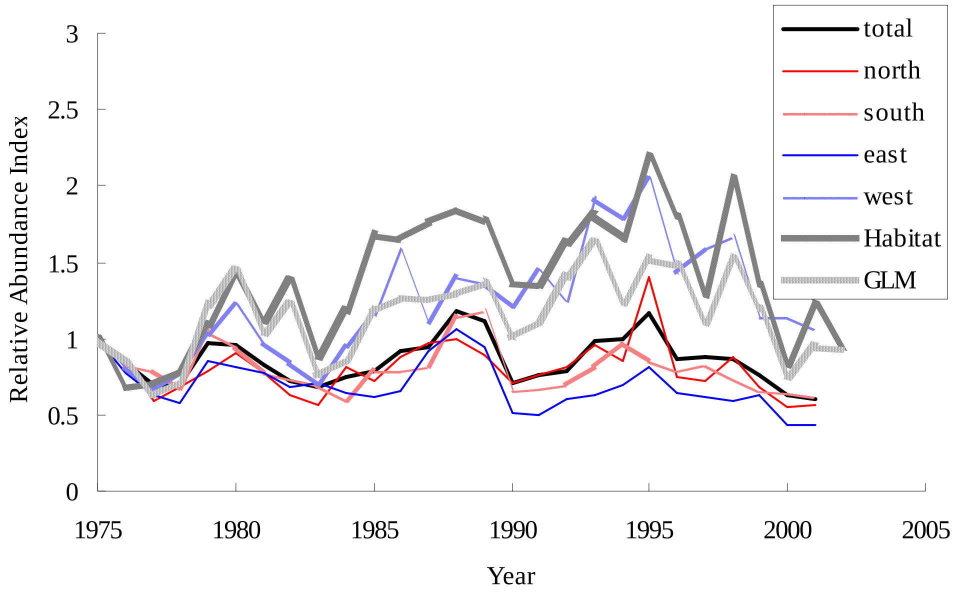


Fig. 3

A: Annual trend of standardized CPUE, s1-s4 are overlapped, completely.

B: Estimated habitat preference

A



B

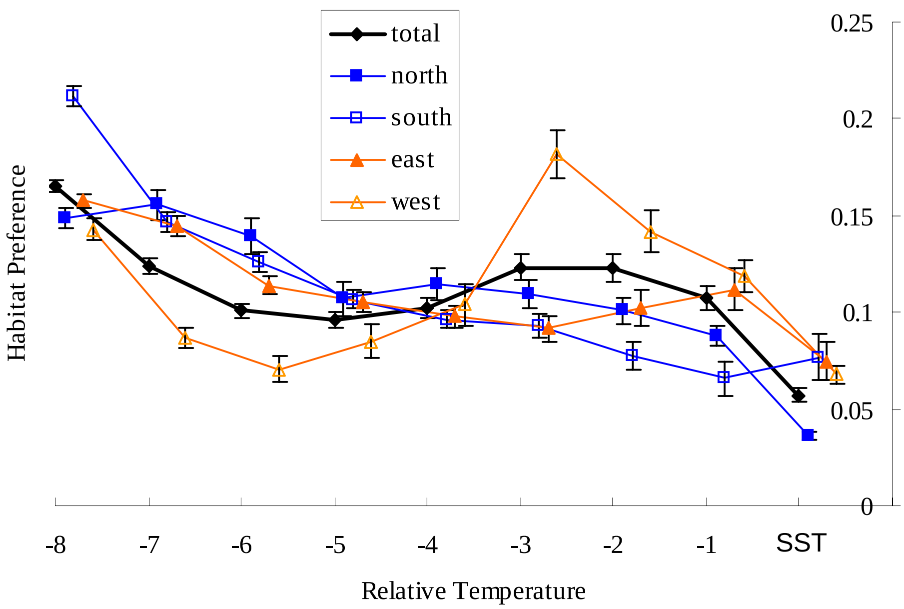


Fig. 4

A: Annual trend of standardized CPUE

B: Estimated habitat preference

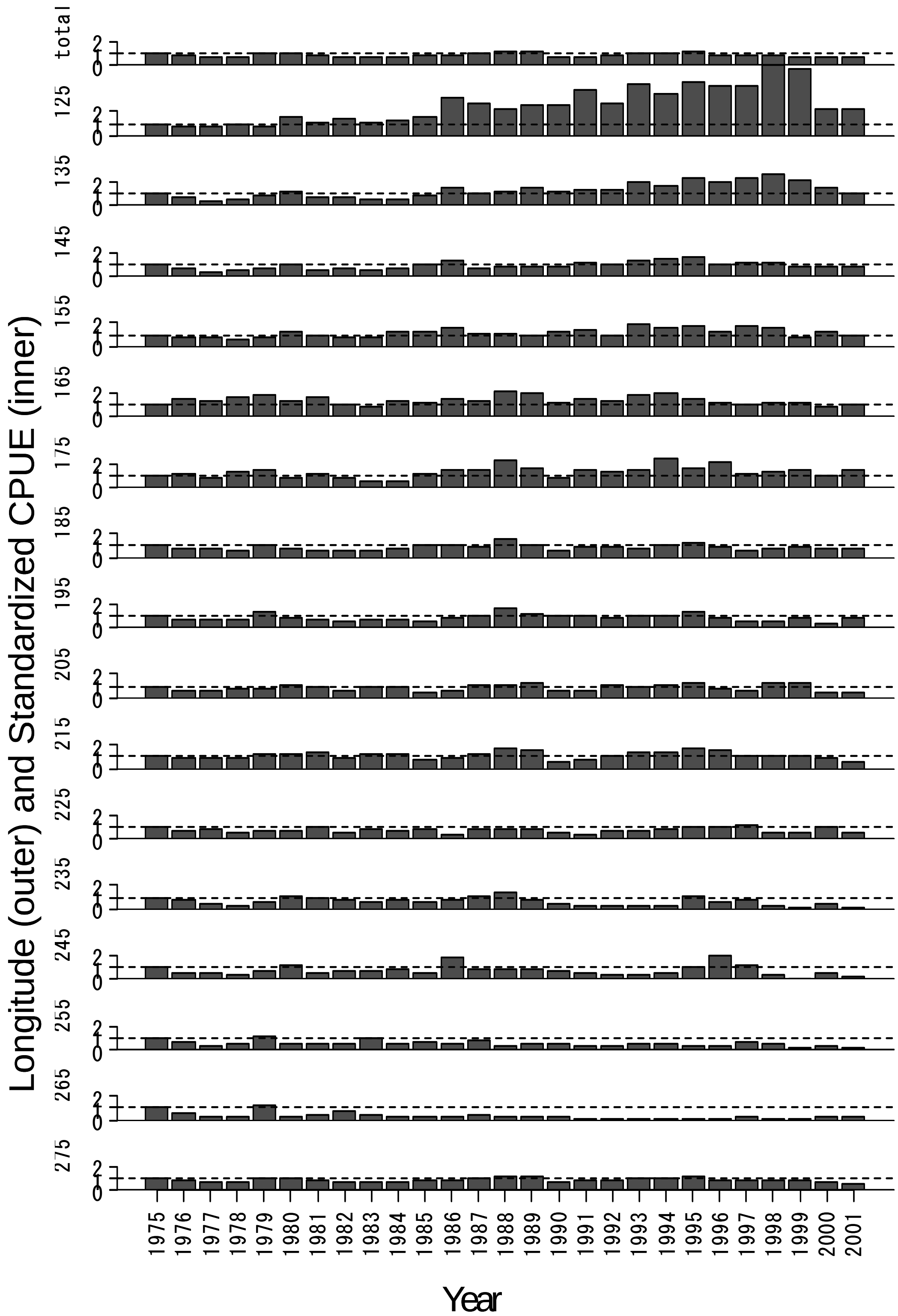
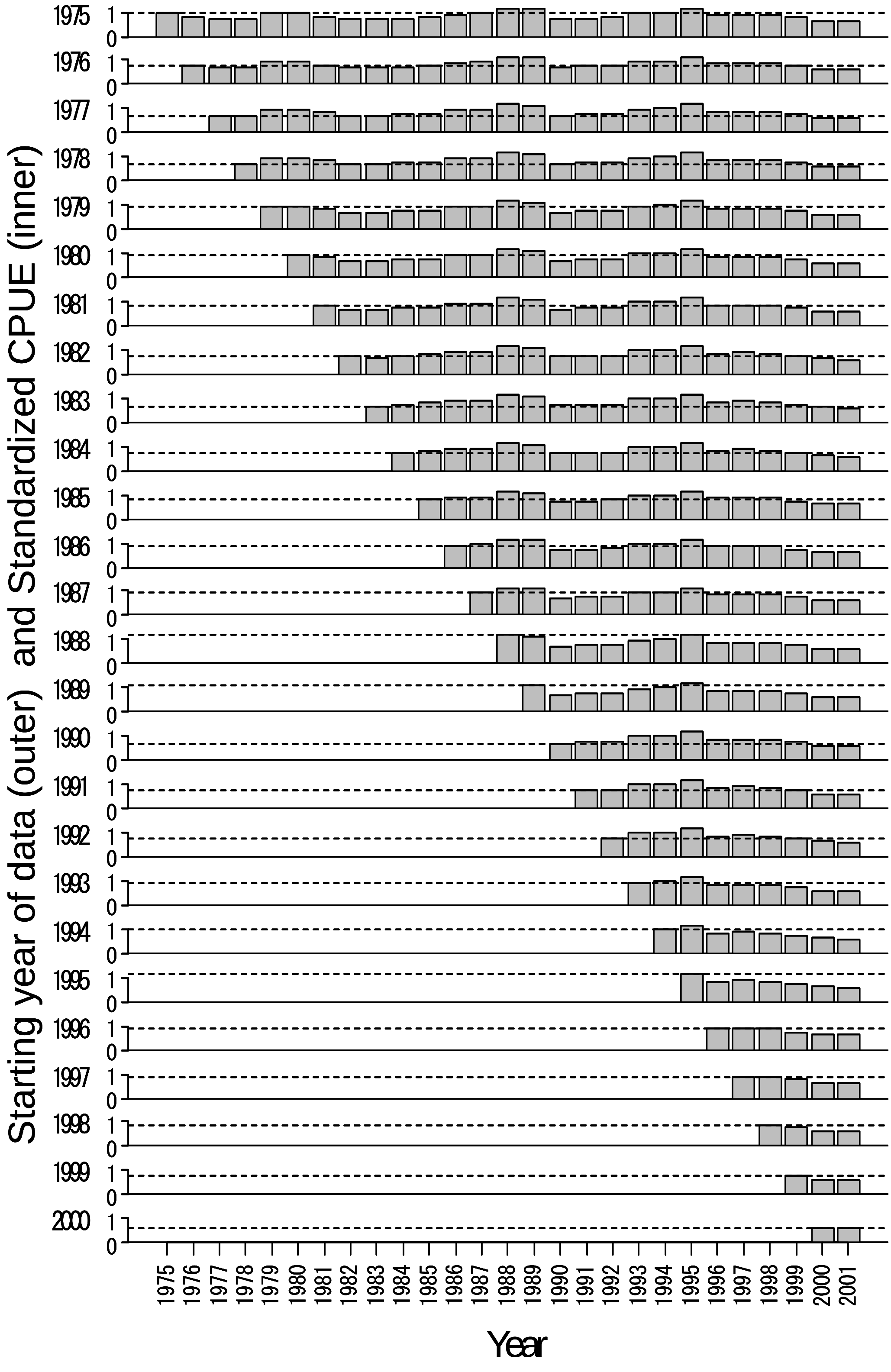


Fig. 5

Annual trend of standardized CPUE. Dashed line shows CPUE in 1975


Starting year of data (outer) and Standardized CPUE (inner)
Year
1975
1976
1977
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1979
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1981
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1983
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1991
1992
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1994
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1998
1999
2000
2001

Fig. 6 A

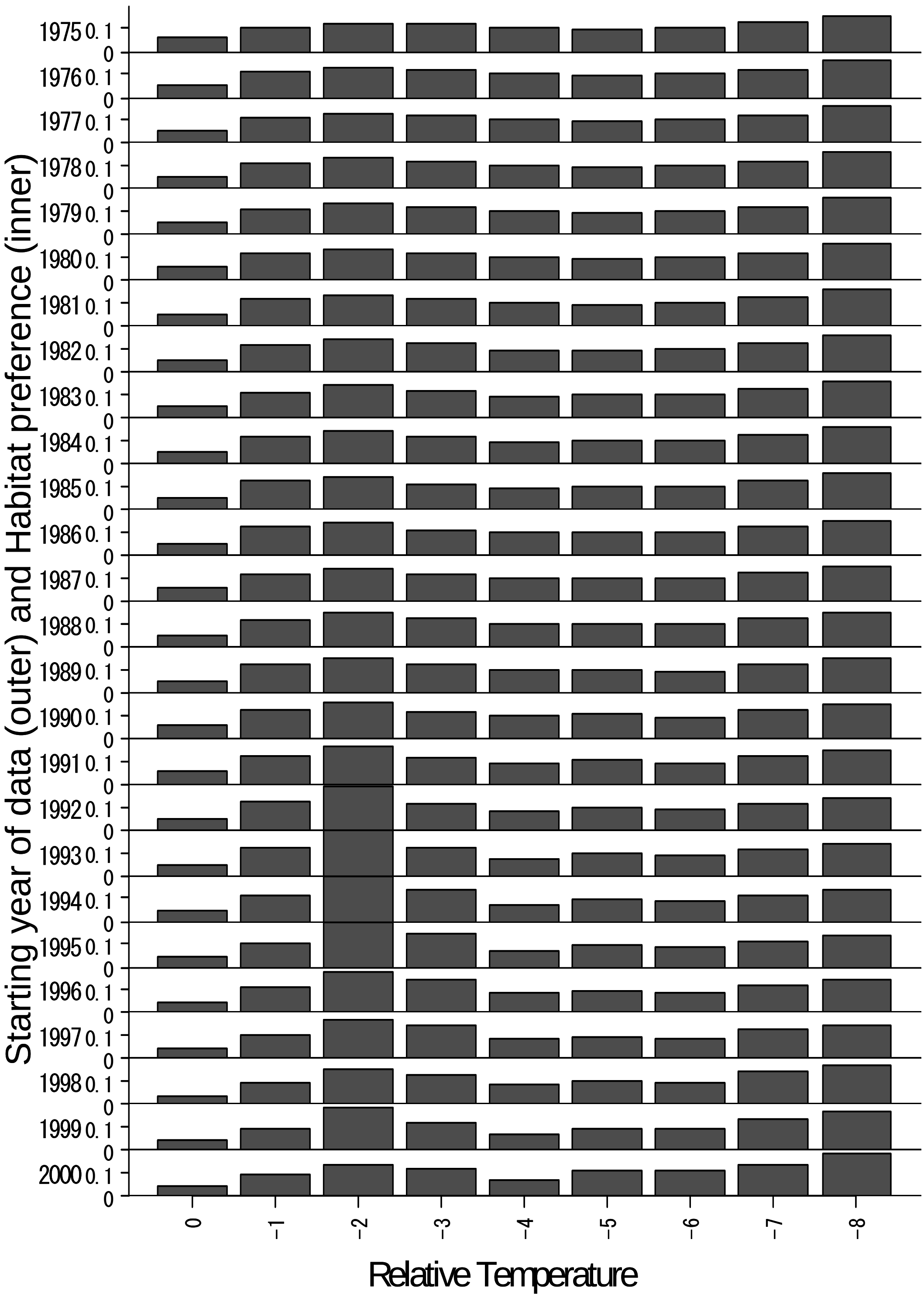

Fig. 6 B

A: Annual trend of sCPUE. Dashed line shows sCPUE in the initial year.

B: Estimated habitat preference

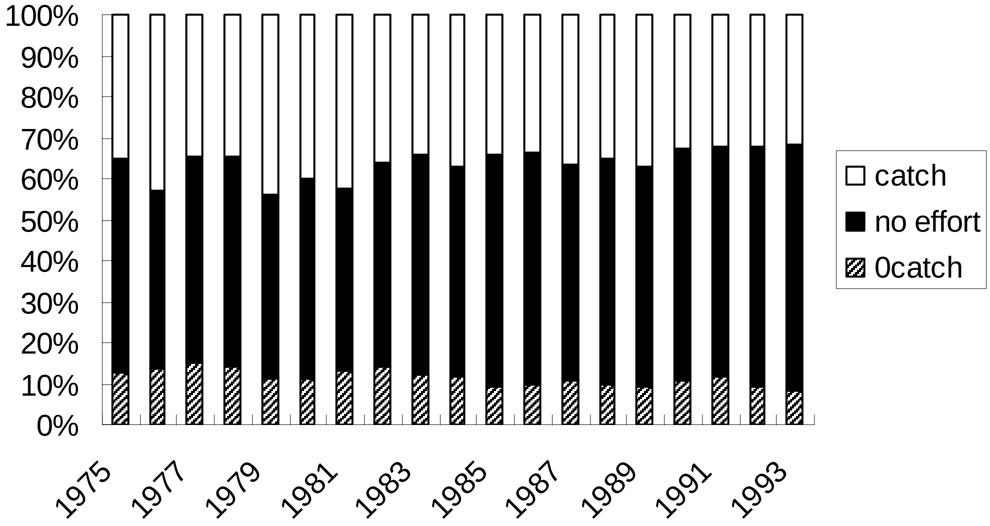

Fig. 7
Frequency of area where there is catch, no effort and 0-catch in target area.

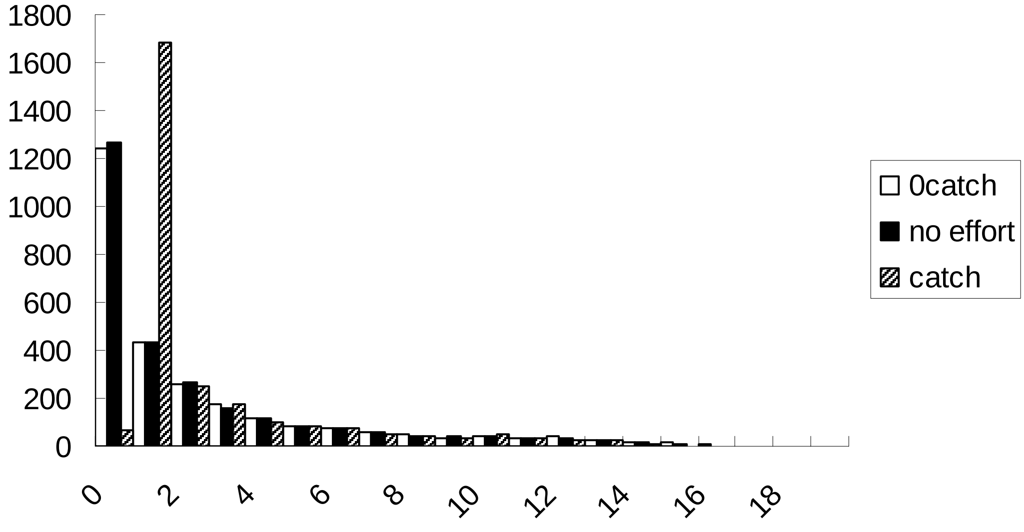

Fig. 8
Histogram of number of areas where have 0-catch, no effort and catch for each years.