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Using statHBS with multiple species to estimate caternary curve [1]

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Abstract

A new method to estimate parameters of longline gear depth by the catenary equation in the statHBS framework using multiple species was introduced. Our previous applications of statHBS have included only a single deterministic catenary curve, but recent information indicates that Japanese longliners have modified gear components historically over time, by area and season.

Introducing multiple species data, which have different vertical distribution patterns into a single standardization process, provides a wider range of vertical information into the model. We examined various scenarios by changing the catenary curve parameters of float and branch line length and catenary angle, and selected an optimal scenario by minimizing AIC. The model estimated the set depth of longline gear changes by area, season and target species.

A test run was conducted using catch and effort data of Japanese longliners in recent years for blue marlin, striped marlin and yellow-fin tuna. Vertical distribution pattern derived from electric tag data was used as a prior. Oceanographic data provided from NMFS was used as habitat information. The result of the test run was rather realistic, e.g., a shallower gear depth in temperate areas and a deeper gear depth in tropical areas. This indicates the fitting of multiple CPUE data may improve estimates of longline shape parameters obtained from statHBS.

Introduction

Statistical habitat model (statHBS; Maunder et. al. in printing) were applied on the standardization of CPUE of striped marlin caught by Japanese offshore and distant-water longliners in the north Pacific striped marlin stock assessment meeting of ISC marling working group held in 2005 (Kanaiwa et al,. 2005). This study revealed that the result of CPUE analysis heavily relied on the assumption about the vertical distribution probability. The estimated historical trend of CPUE changed largely when the vertical distribution probability of striped marlin was assumed to be regulated by different environmental factors, relative temperature, absolute depth and ambient temperature (ISC 2005). Because there is no definitively reliable information about the mechanisms of the striped marlin diving behaviors, ISC marlin working group agreed that it is premature to use the result of CPUE analysis by statHBS in the stock assessment of striped marlin (ISC 2006).

Multiple species statistical habitat based standardization (mstatHBS) is expanded from statHBS. The statHBS fix the catenary curve and estimate habitat preference probability and annual trend of stocks by the maximum likelihood method. However catenary curve can be changed by areas, seasons, and historical dates and the detailed configuration of longline gear such as length of float and branch line, shortening ratio of set gear, material of gear (specific gravity) have been changed at least to some extent by time even for the operation targeting same species with same number of hooks per basket (HPB) (Sawadaishi, pers. comm.).

In the present study, we propose a new method to enhance the reliability and stability of the result of statHBS by using the longline catch information of fishes other than a species subjected to the analysis.

Method

We make some scenarios of different catenary curves by changing parameters in the formula which is shown below and estimate habitat preference probability and annual trend of stocks by using statHBS with maximum likelihood method. After getting each species log likelihood we just summed up it to calculate total log likelihood. We use calculated AIC value of each scenario to estimate the most optimal catenary curve in those scenarios.

The detail of the statHBS is explained by Maunder et. al (in printing). We explain about the detail of scenarios which we use. We use below equation (revised from Yosihara 1951) as catenary curve. We define *j* as the order of hook among basket and n as HPB;

$$D_j = h + \frac{nl}{2}\left\{\sqrt{1+\cot^2 s} - \sqrt{(1-2\frac{j}{n})^2 + \cot^2 s}\right\}.$$

Here we define D_j as depth of *j*th hook, *l* as the length between hooks, *h* as summary length of float line and branch line (*h1*+*h2*) and *s* as approach angle of main rope which is represented in radian (Fig. 1). We made the scenario by changing value of *h* sequentially from 0 to 95 m by 5 m interval and three typical values of *s*; 0.7 (about 40 degree), 1.04 (about 60 degree) and 1.3 (about 75 degree).

Catch and effort data for yellow-fin tuna, blue marlin and striped marlin from the Japanese offshore and distant-water longline fishery in the period between 1980 and 2004 was aggregated by month, 5-degree square and the number of hooks between floats (HPB) for the analysis. Vertical distribution probability of these three species were assumed to be regulated by the relative temperature to the surface, and the probabilities of these three species by each 1 degree Celsius obtained by Miyabe (personal comm..) for yellow-fin tuna, Yokawa (2005) for striped marlin and Saito (2005) for blue marlin.

We used seawater temperature difference relative to sea surface temperature (SST) as habitat information. We obtained the historical oceanographic data in the north Pacific from 1980 to 2003 from PIFSC (NMSF) and assumed the oceanographic condition in 2004 was same as 2003.

Our target area for this study is the North Pacific Ocean as shown by the gray line in Fig. 2.

Result

First we compare scenarios whose value of s is set as 1.04. The values of AIC by h are shown in Fig. 3a and b. For Area 01 and 03, relatively longer length of branch and float line (deeper setting) catenary curves are selected and for Areas 02 and 04, while shorter branch and float line (shallower setting) catenary curves are selected in Areas 01 and 03. However for Area 01 and 03, the estimated set depth of gear became unrealistically short length of branch and float lines, so we tested scenarios of other s values than 1.04 to estimate the optimum value of s. Table 1 is showing the values of AIC. In both areas, scenarios of moderately short length of branch and float lines are adopted with scenario of s=0.7 (and the values are realistic). By using the optimal catenary curve, CPUE of blue marlin, yellow-fin tuna and striped marlin are standardized in each area (Fig. 4abc) and estimated and observed habitat preference probabilities are shown in Fig. 5.

Discussion

The results of this study indicates that mstatHBS is a powerful way to estimate catenary curve by oceanography and underwater behaviors of fishes with adequate data of fishery. If we only use single species information to estimate catenary curve, the vertical habitat of the fish would not cover entire range of the relative temperature (or depth) of catenary curve (vertical range of longline gear deployment), so the estimated catenary curve may become unrealistic and/or unreliable one. However using multiple species information, habitat preference information would cover wider vertical range of relative temperature so it would bring enough amount of information to the model for the estimation of parameters of catenary curve. This is the most characteristic point of mstatHBS.

In this study, we did not estimate any parameter of catenary curve by using maximum likelihood method directly, because model has discontinuous component with catenary curve so even if we try to estimate the parameters, it is hard to converge the likelihood. We are considering the way how building in the catenary curve's parameter without any discontinuous component. For example if we use spline curve as habitat data and habitat preference probability to eliminate discontinuous components of likelihood, it may work well. This is one of future works.

In this study, we focus to explain methodology of mstatHBS, so the input data which we use in this paper has many problems. We used 5x5 girded data because of calculation time and memory. However we may have to use set-by-set data because in mstatHBS we assume each species are caught by same set of longline. We need to solve computing problem but it is not essential problem. However this problem make our result preliminary one.

When we summed up log likelihood of each species, we did not assume any weight for each species because of no information. If we can assume that one species is more important to estimate catenary curve, we should weight it more than other species.

We use relative temperature as habitat preference curve of each species as prior information. While the possibilities of other environmental factor such as ambient temperature was also pointed out in the last ISC striped marlin stock assessment meeting (ISC 2005). The model selection by AIC value like this study may be able to become one of solutions.

We know that generally the length of float and branch line of Japanese longliners becomes longer in the tropical area than in the temperate area this research's result conform it.

The mstatHBS method described in this document would have possibility to increase reliability of the result of currently used statHBS if the vertical distribution pattern of multiple tuna and billfish species and their variability by area, season and size classes were available. The difference of historical change of stock size of each species used in the mstatHBS may change the species composition of the longline catch and it would affect on the result of the mstatHBS. It could be overcome if the mstatHBS could standardize CPUEs of multiple species at once within the model.

In the mstatHBS, the area should be carefully stratified so that we can assume the species composition of tunas and billfishes would be affected by the change of environmental condition. In addition, Yokawa et al., (2005) shows the vertical distribution pattern of striped marlin changed largely between the temperate and tropical areas. Past electric studies indicates that the vertical distribution pattern of tunas and billfishes changed largely between the warmer and cooler side of big water front, such as the front between Oyashio and Kuroshio (e.g. Takahashi et al., 2003; Saito et al., 2005).

Because it is rather difficult to identify each longline set being conducted cooler or warmer side of water front especially in the period before the 1980s when the precise oceanographic information is not available, mstatHBS would be more effective in applying species which mainly distributes in tropical or subtropical area where the oceanographic condition is relatively stable.

References

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Table 1. Values of AIC for Area 01 and 03 under each scenario. Black (reversed) cell shows minimum (selected) values.

Area 01

	35	40	45	50	55
1.3	111151270	112184270	113083270	113049270	113404270
1.04	108665270	109994270	110065270	110495270	110975270
0.7	113404270	107559270	107535270	107829270	107885270

Area 03

	35	40	45	50	55
1.3	80878670	82980270	85114370	86855170	85655270
1.04	81057370	82499170	82353970	83128370	81741570
0.7	85655270	79667470	79201770	78951470	81753570

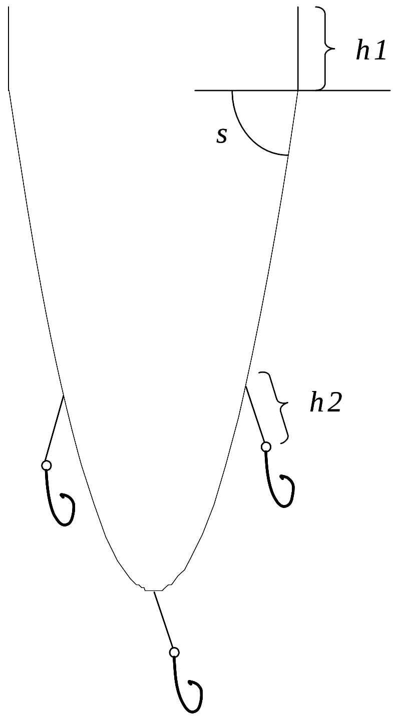


Fig. 1 Catenary curve and description of parameters

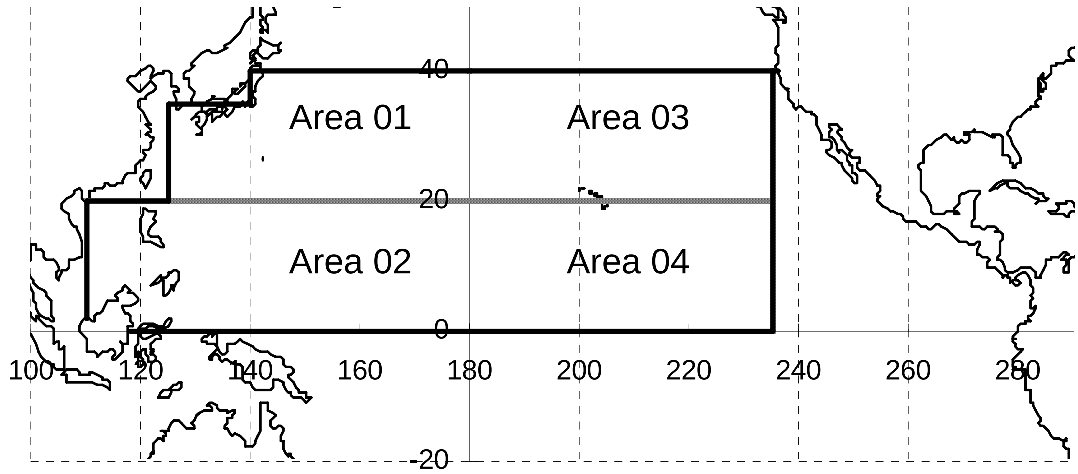
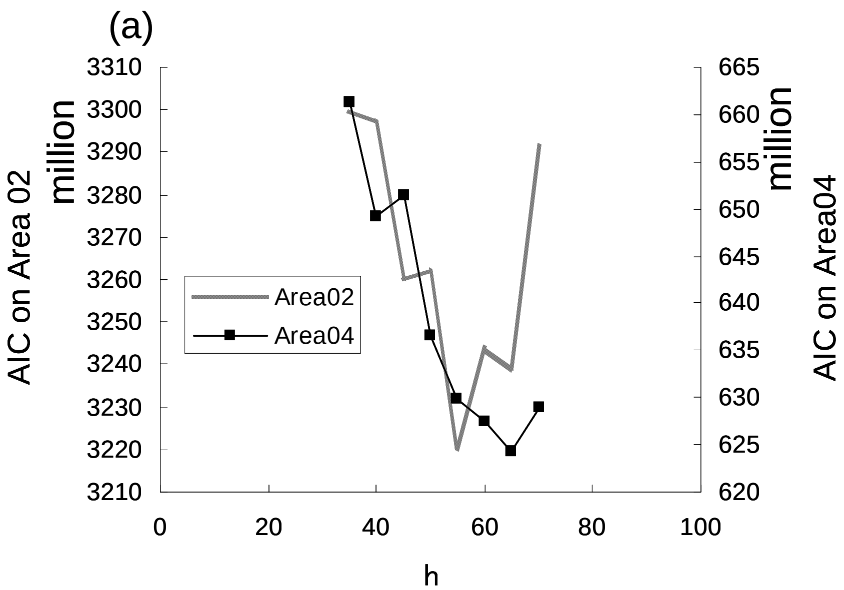


Fig. 2 Target Areas



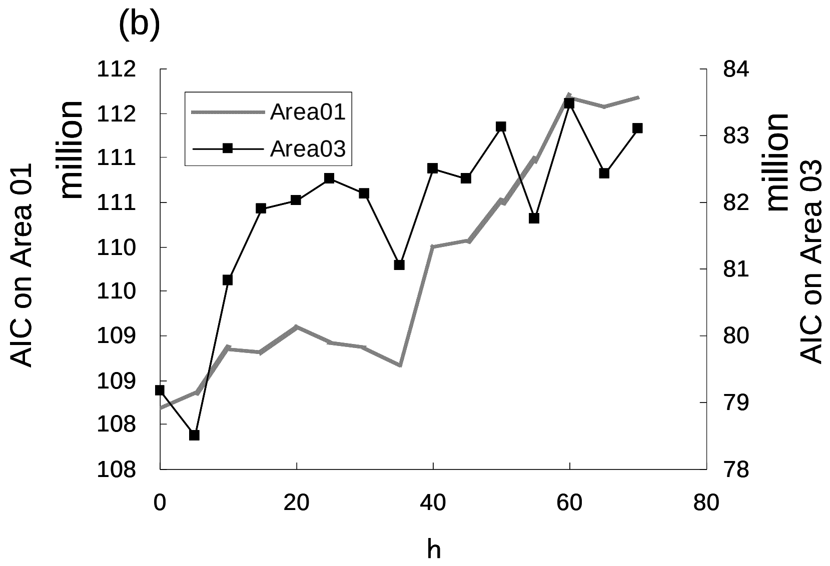


Fig. 3 Values of AIC for each area

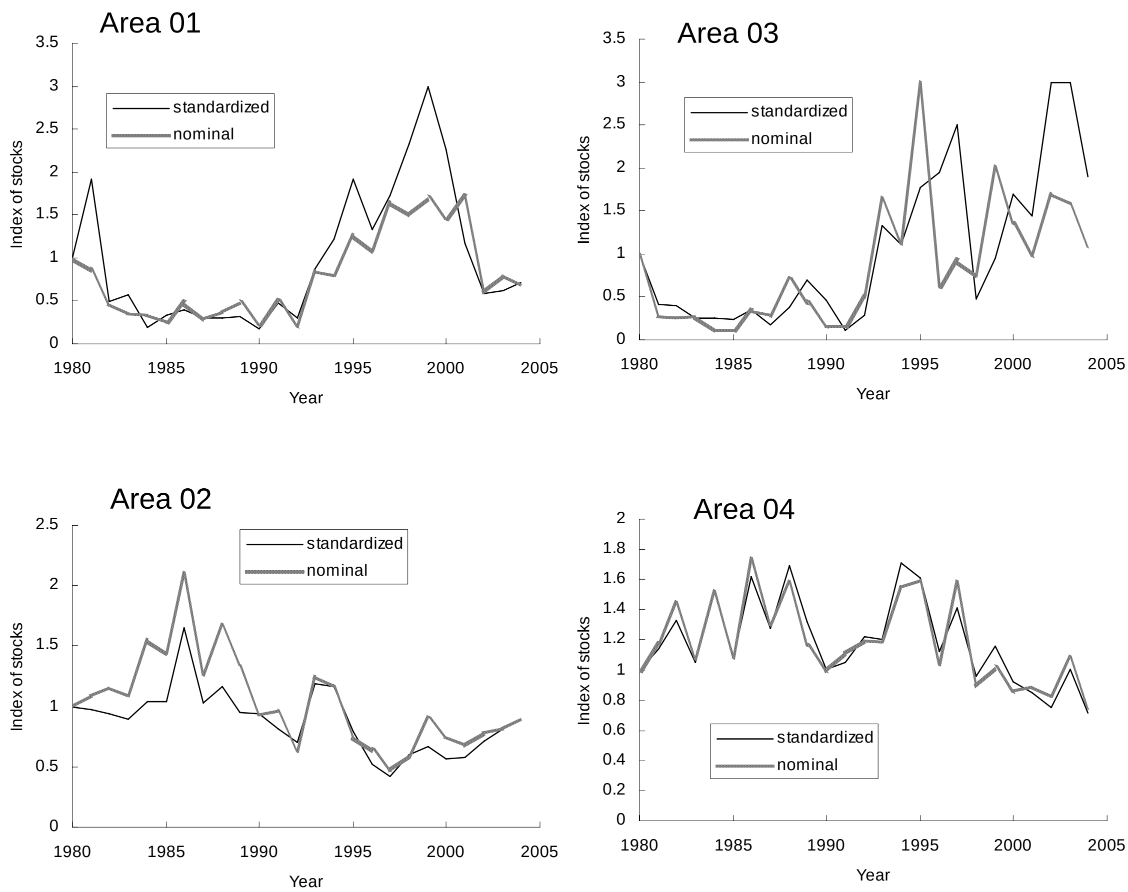


Fig. 4a Standardized and nominal CPUE of blue marlin

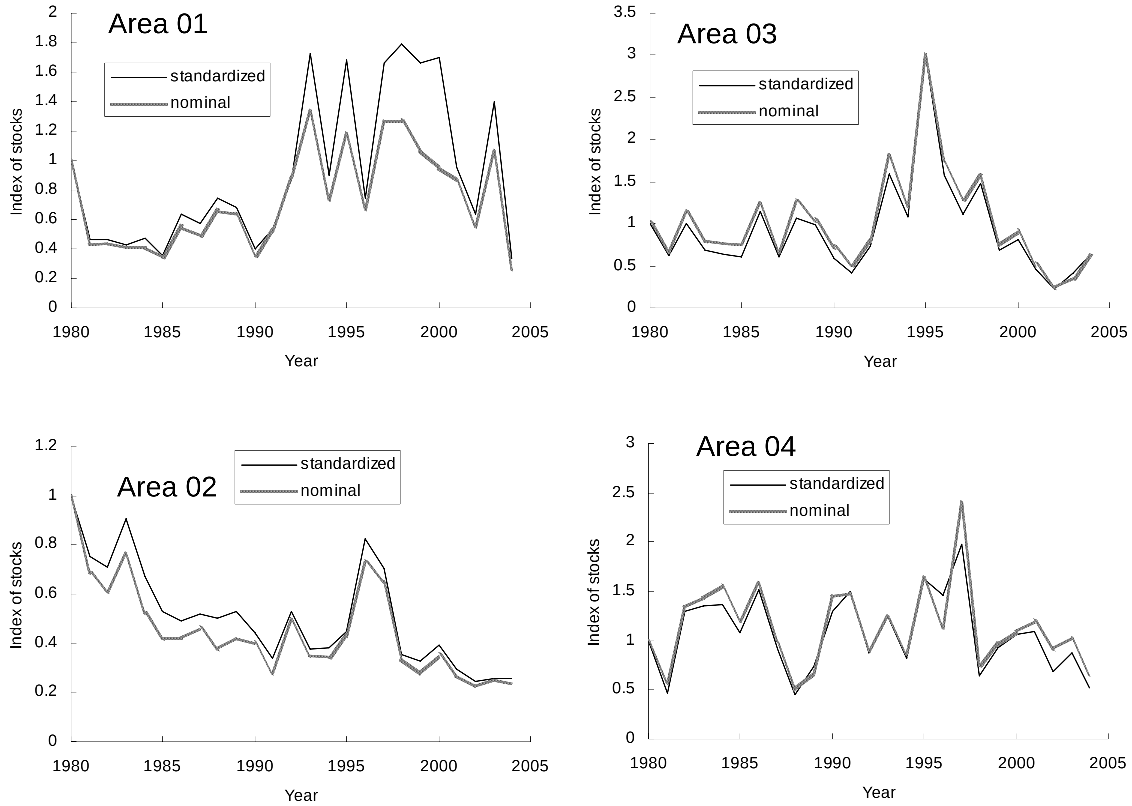


Fig 4b Standardized and nominal CPUE of yellow fin tuna

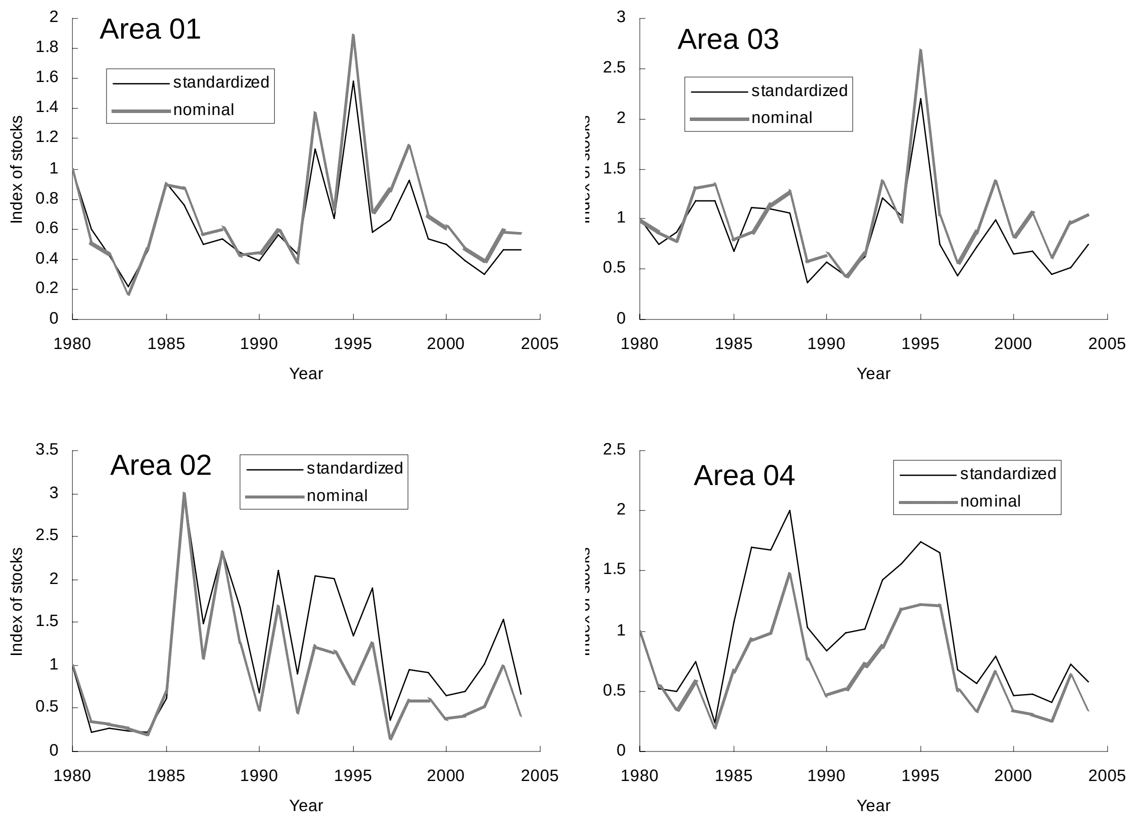


Fig. 4c Standardized and nominal CPUE of striped marlin

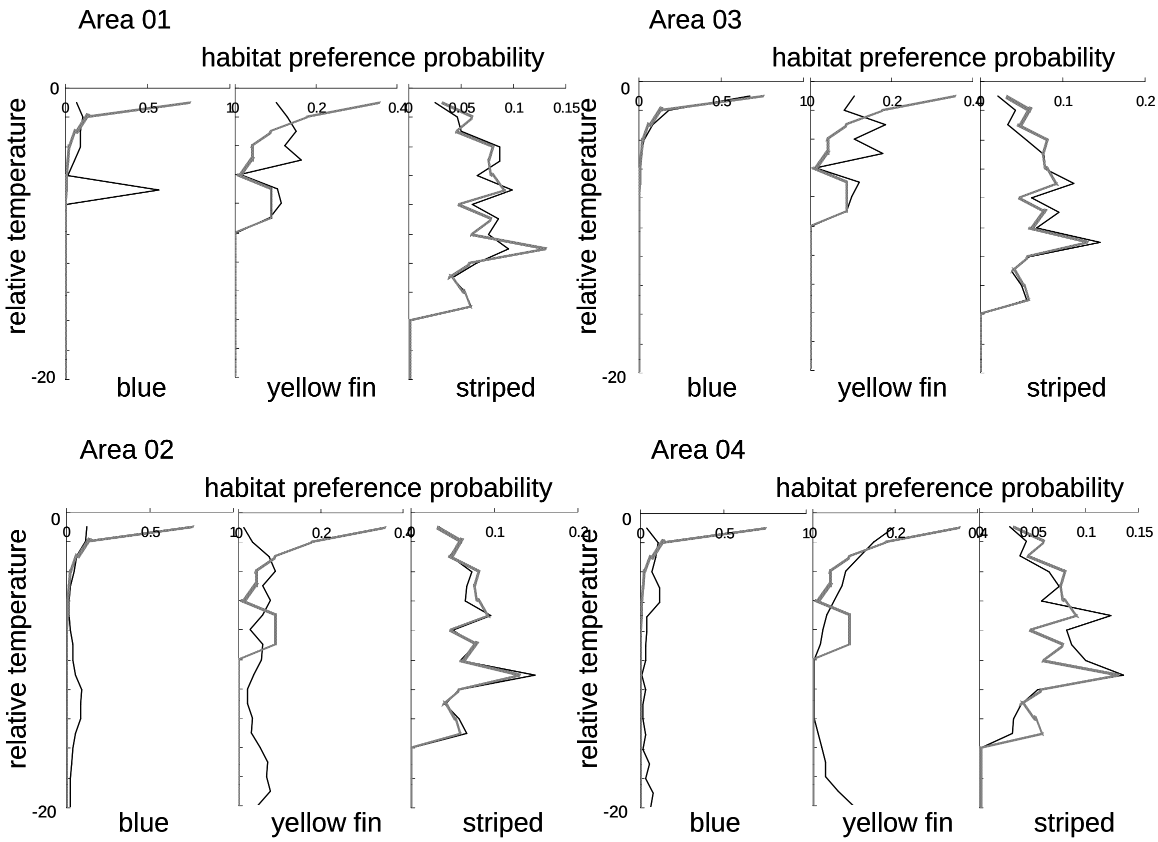


Fig. 5 Habitat preference probability, black line is estimated one and gray line is observed (input) one.