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The analysis of stock structure for striped marlin in the North Pacific Ocean

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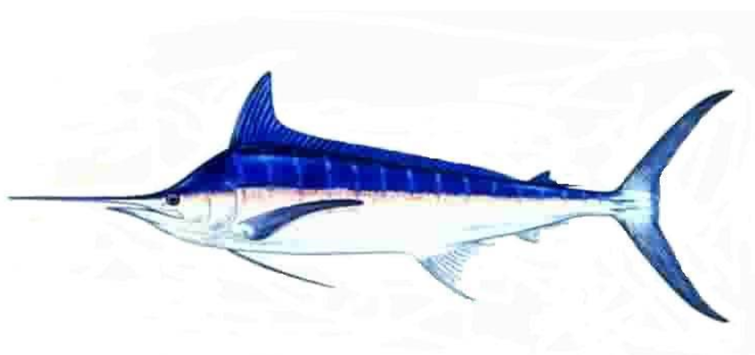

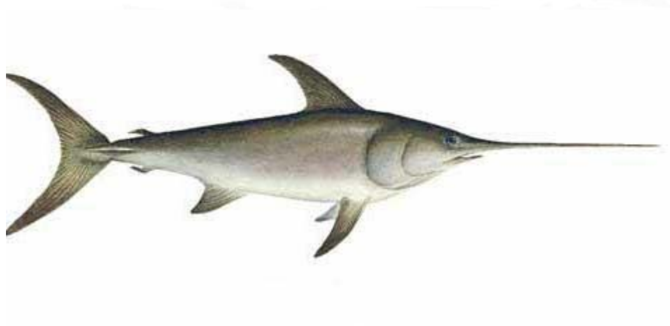

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Introduction

Clarification of stock structure for stripe marlin in the North Pacific Ocean is required to determine stock management unit. The population of striped marlin in Pacific Ocean expands all of Pacific Ocean and there is some proof showing genetic difference between the populations in North and South Pacific, especially between around Japan and Australia. However there is no significant proof that the stocks are separated between North West and North East Pacific Ocean. However the yearly positive CPUE trend and zero catch ratio are different among the regions of North Pacific Ocean (Kanaiwa and Yokawa 2009), these suggest the probability of spatial stock structure in North Pacific Ocean. Of course these commercial fishery patterns are affected by the change of commercial fishery's gear pattern and target fish. In this paper, we search the optimal separation line under the assumption that there are two stocks of striped marlin in North Pacific Ocean as first step of stock structure analysis in this species.

Data set

Catch and effort data used in this analysis was provided from the Japanese longline fishery statics compiled at the National Research Institute of Far Seas Fisheries for 1975-2006. This data has the information of catch number and number of hooks and aggregated by month, 5x5 degree blocks area and gear configuration, i.e. the number of branch lines between floats (hooks par baskets: HPB).

HPB ratio analysis

If HPB pattern is not stable, it makes hard to realize the stock structure, because the commercial fishery pattern may affect HPB pattern and the change of fishery pattern can make confuse the relationship between stock structure pattern and stock abundance index which is calculated from fishery data.

GLM analysis with multinomial error distribution is used clustering years to find a term while HPB pattern is stable. The model is follow;

hook's number in each HPB ~ year cluster + multinomial(ε).

The method of tree regression model with AIC as evaluate index is used to cluster years. For example, when we consider the term between 1975 and 2006, we set one separation year of lowest AIC by comparing AICs of what the data divided into two clusters in each year. And then, second optimal separation year was searched using same procedure, These process was repeated until the minimum AIC value was attained. one after the year, calculate AIC for each separation year and search the optimal separation year. When optimal separation year become 1980, then we set a term between 1975 and 1980 as first year cluster and another terms between 1981 and 2006 as second year cluster, and search second separation year similarly as long as AIC will reduce.

We could separate 6 year clusters between 1975 and 2006, i.e. 1975-1981, 1982-1986, 1987-1989, 1990-1994 and 1995-2006 by this method (Fig. 1). These means, in each cluster, there is no proof HPB pattern was changing yearly. In the religion of East side of North Pacific Ocean, there is few operation of Japanese longline after 1980s (Kanaiwa and Yokawa 2009), so earlier year cluster is better to analyze spatial distribution in North Pacific Ocean. We decide to use the data between 1975 and 1981 for later analysis.

Area separation

To define the stock structure to manage striped marlin in North Pacific Ocean, first we check this spatial distribution by using GLM method. The caught data of striped marlin in North Pacific Ocean has many zero catch data. Delta-type two step method (Lo et al. 1992) was used for estimating standardized CPUE of striped marlin. The formula of the first step model is following:

p ~ year + gear + hooks + qt * (poly(lon, 5) + poly(lat, 4)) + binomial error.

Here p is the ratio of non-zero catch, year is the year, gear is the category of HPB (same with Ichinokawa and Yokawa 2006), qt is the quarter of season, hooks is the number of hooks, poly(variable, n) is a fitting polynomial equation of n-th order for variable, lon is longitude and lat is latitude. The reason why interaction among only seasonally and spatial factors is that many marlins have seasonal migration. The formula of the second step model is following:

pCPUE ~ year + gear + qt * (poly(lon, 5) + poly(lat, 4)) + Gaussian error.

Here pCPUE is the catch per each hook of positive catch. Standardized CPUE was calculated from the product of estimated values of least squared means derived from the two models as (ratios of non-zero catch) * (CPUE of positive catch). These two models are used to show brief spatial pattern of CPUE. Both models are tried both direction stepwize method to reduce factors and initial model result as optimal models.

Figure 2 shows the estimated spatial pattern of these two steps and standardized CPUE. All results show that north 20 degree is a changing point. In other word there is no similar pattern in longitude among these results.

So we fix north 20 degree as the separation line of latitude for two stock structure and search the optimal separation line for longitude by using AIC as evaluation index. Here, the formulas of the first and second step models are following:

p ~ year + gear + qt + hooks + qt * sarea + binomial error

and

pCPUE ~ year + gear + hooks + qt * sarea + Gaussian error.

Here sarea is defined by where we set the separation line for longitude. To define sarea, we change both northern (larger 20N degree) and southern (0N - 20N) separation lines of longitude by 5 degree step, respectively and calculate AIC each by each step.

Result and Discussion

In the result, we can get two separation lines from these two models (Figure 3). These results are independent but almost similar. Retrospective analysis was done for this analysis. Table 1 and 2 show evaluated separation lines for each step of retrospective analysis. All separation lines are close to original one so this result is very robust. And the estimated positions of the stock boundaries obtained by the 0 catch ratio and by the positive CPUE were similar with each other. This result indicates that the largest gap of CPUE of Japanese longliners was existed in between the coastal side of Japan and Hawaii, not in between EPO and Hawaii.

These separation lines were estimated under the assumption which there is two stocks in Northern Pacific Ocean. Preliminary analysis shows more area separation make more optimal result by using same models. We should revalidate this assumption also.

Even if we want to get optimal separation with larger than two areas by this paper's method, too large calculation makes difficulty. In such a case we need to use some alternative clustering e.g. k-means clustering method. This may be future work.

References

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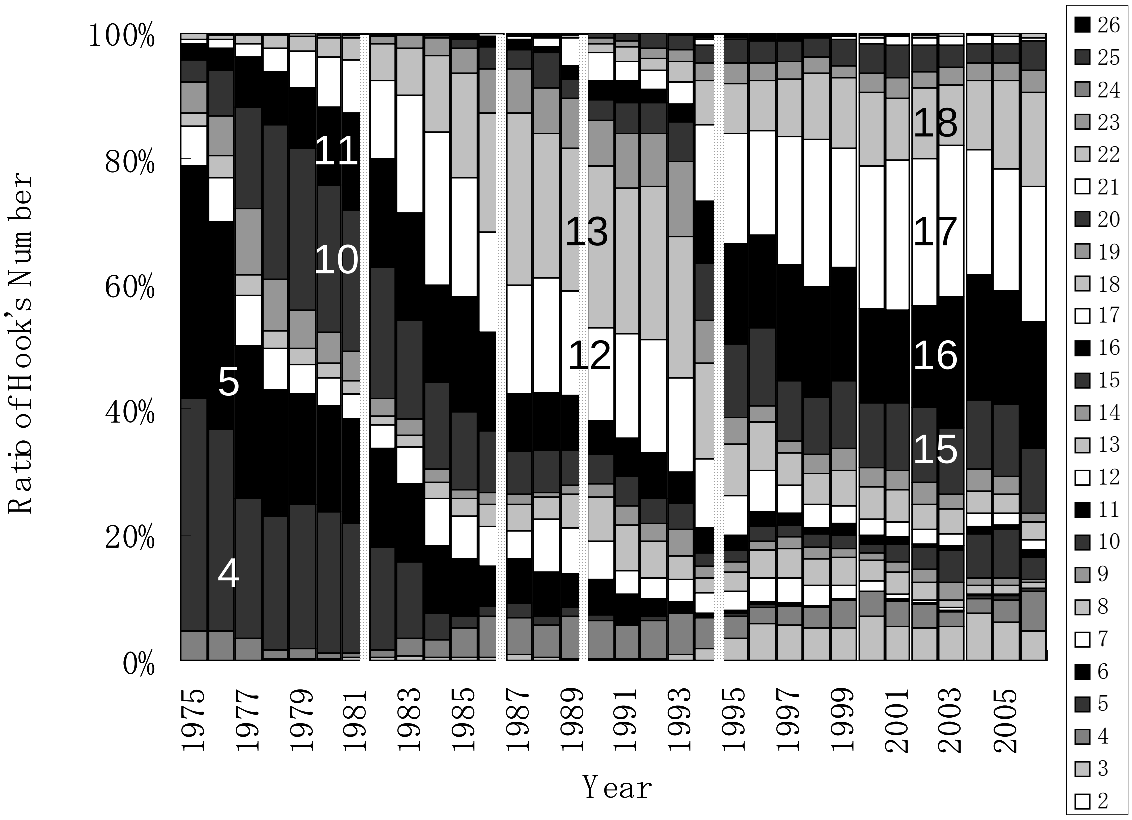


Figure 1

Yearly change of HPB pattern. Dashed line means optimal separation year to cluster years.

A1

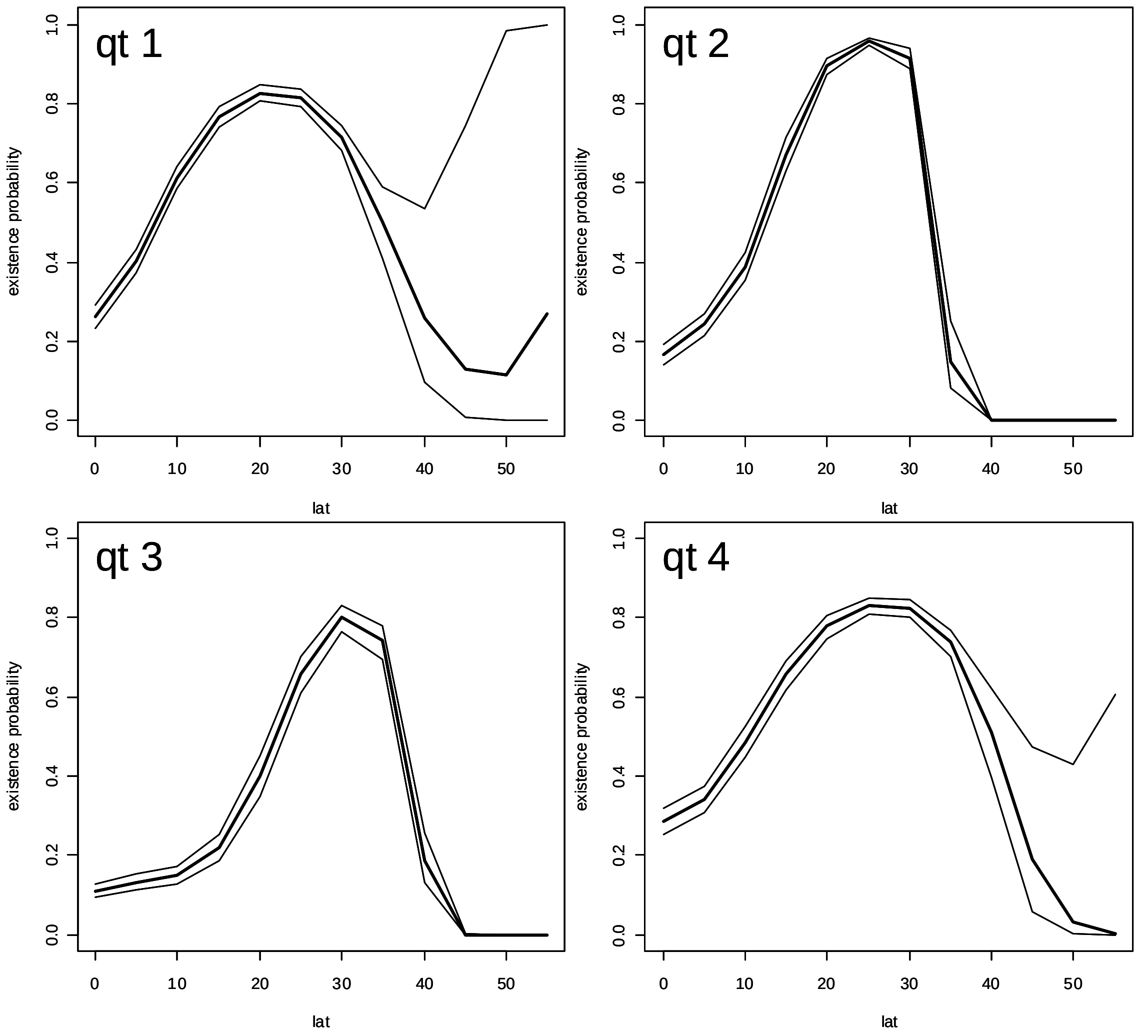
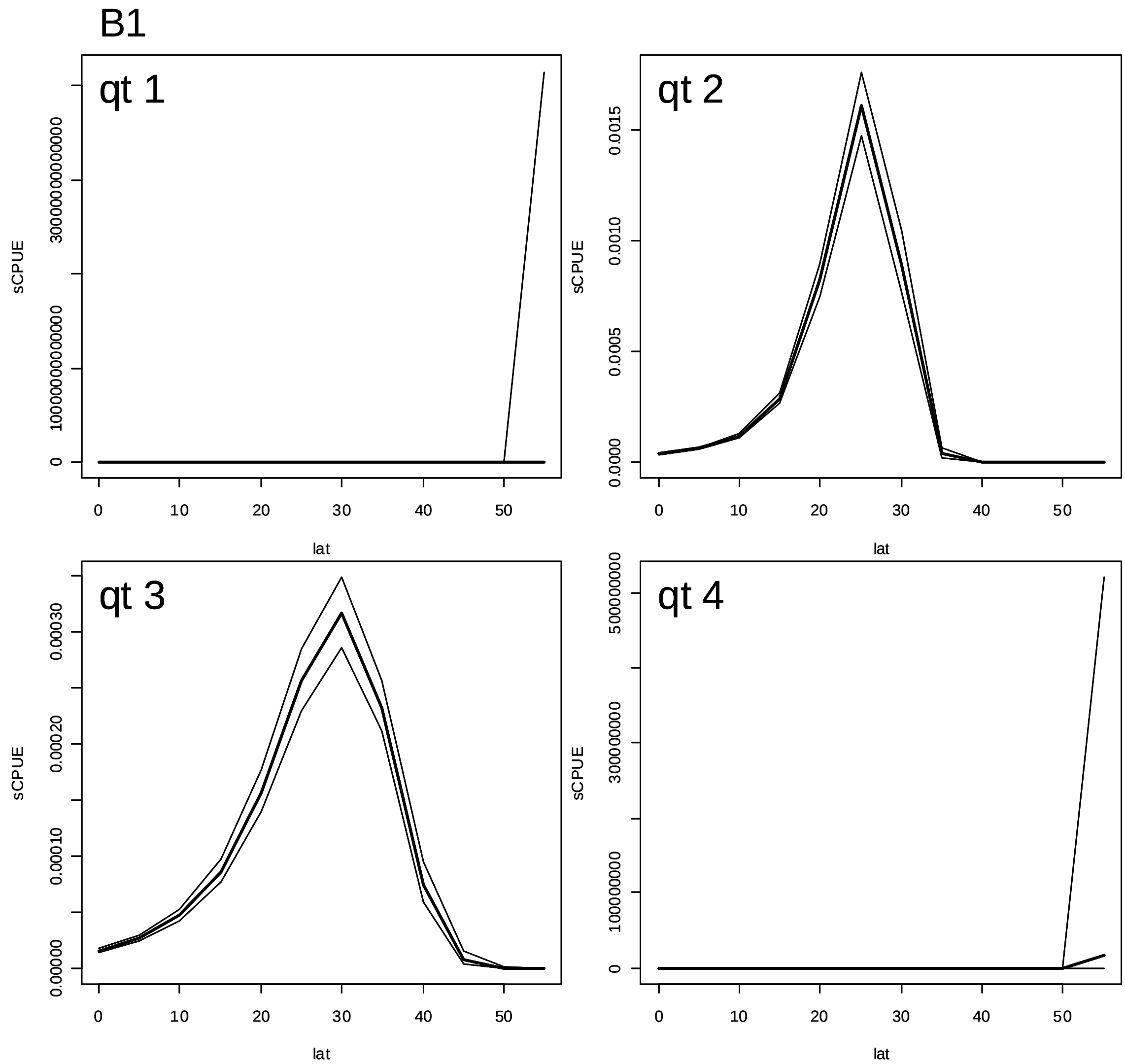


Figure 2

Spatial pattern of ratio of zero-catch(A1 and B1), positive CPUE (A2 and B2) and standardized CPUE (A3 and B3) for latitude and longitude.



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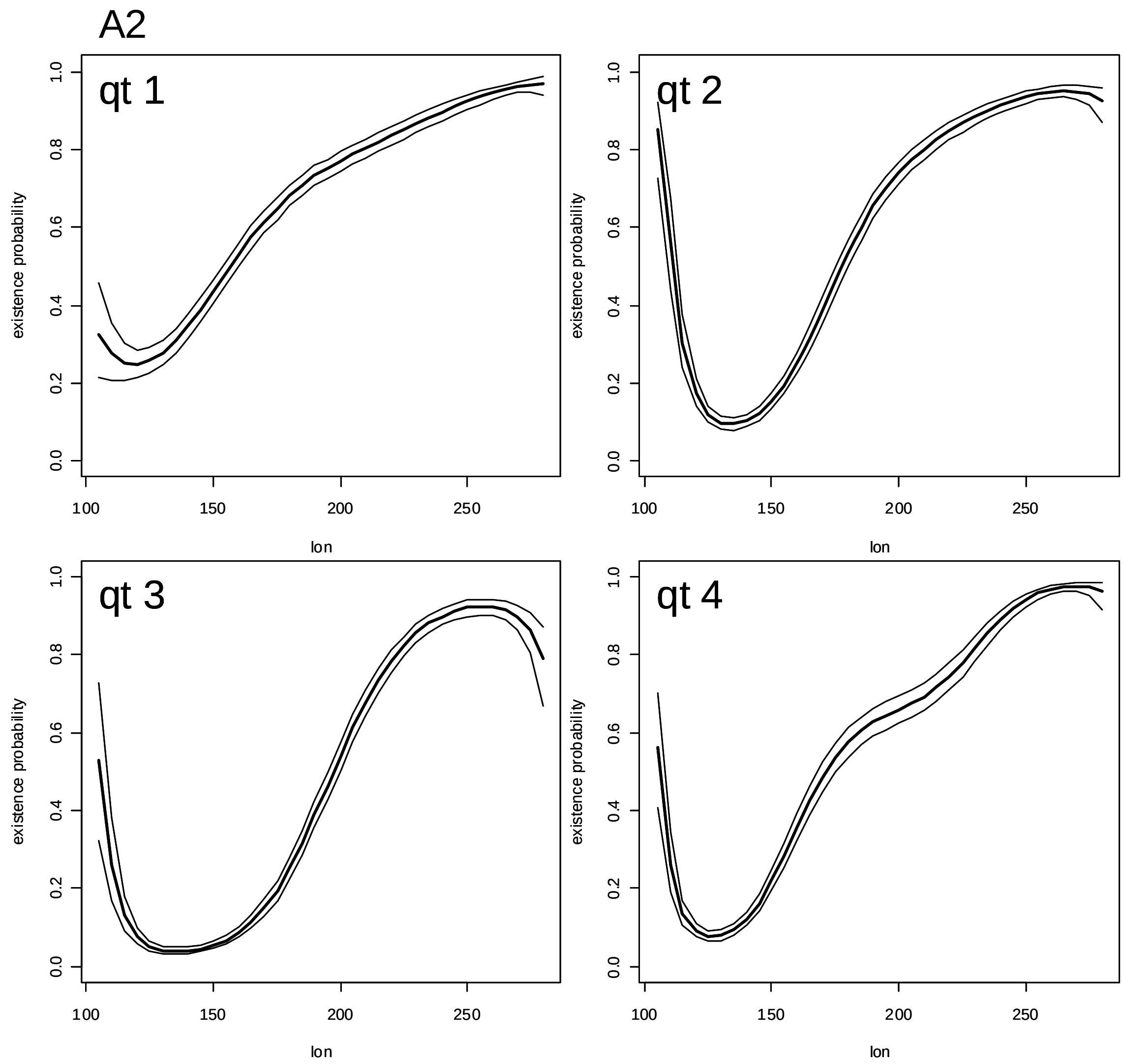

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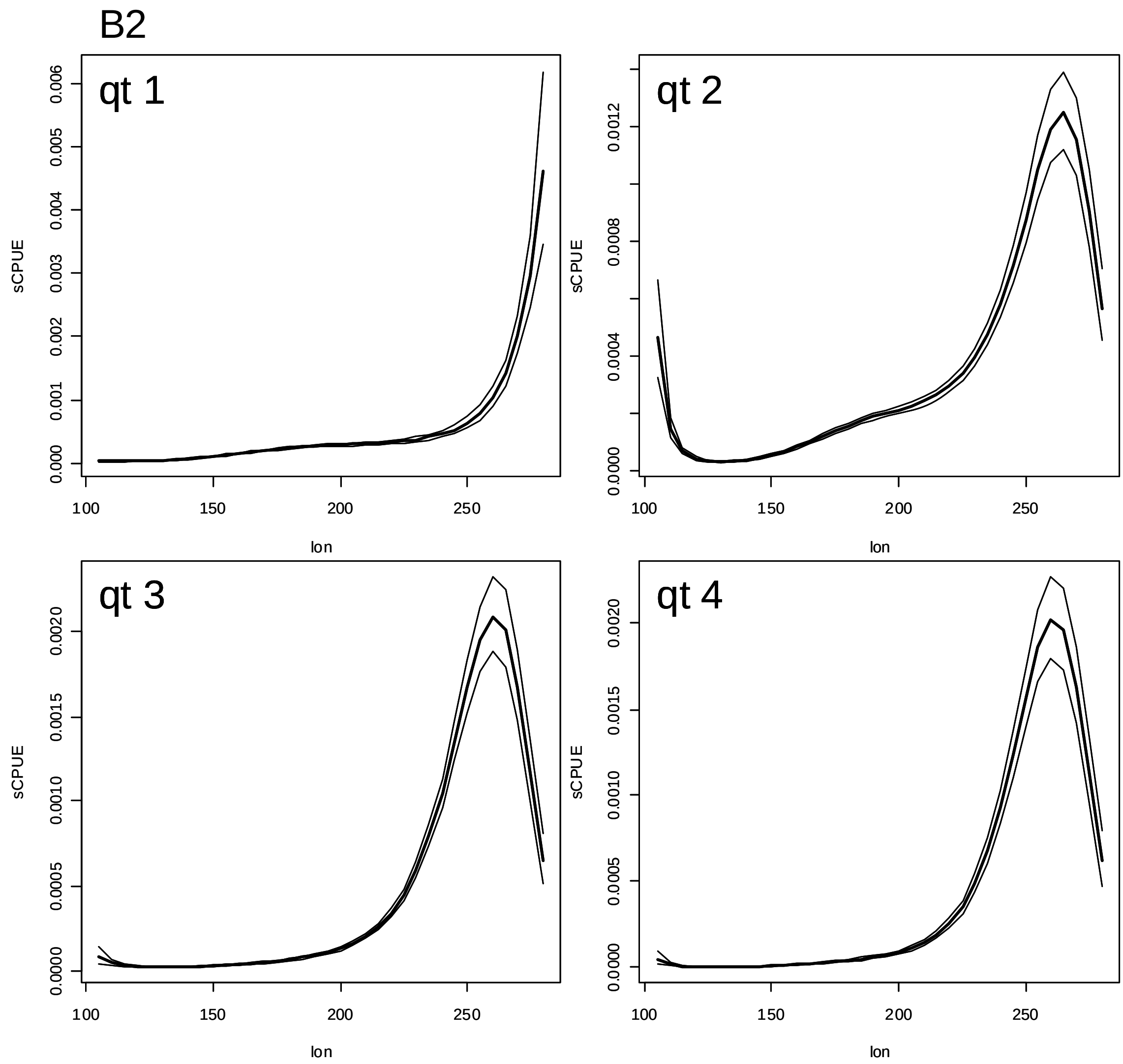

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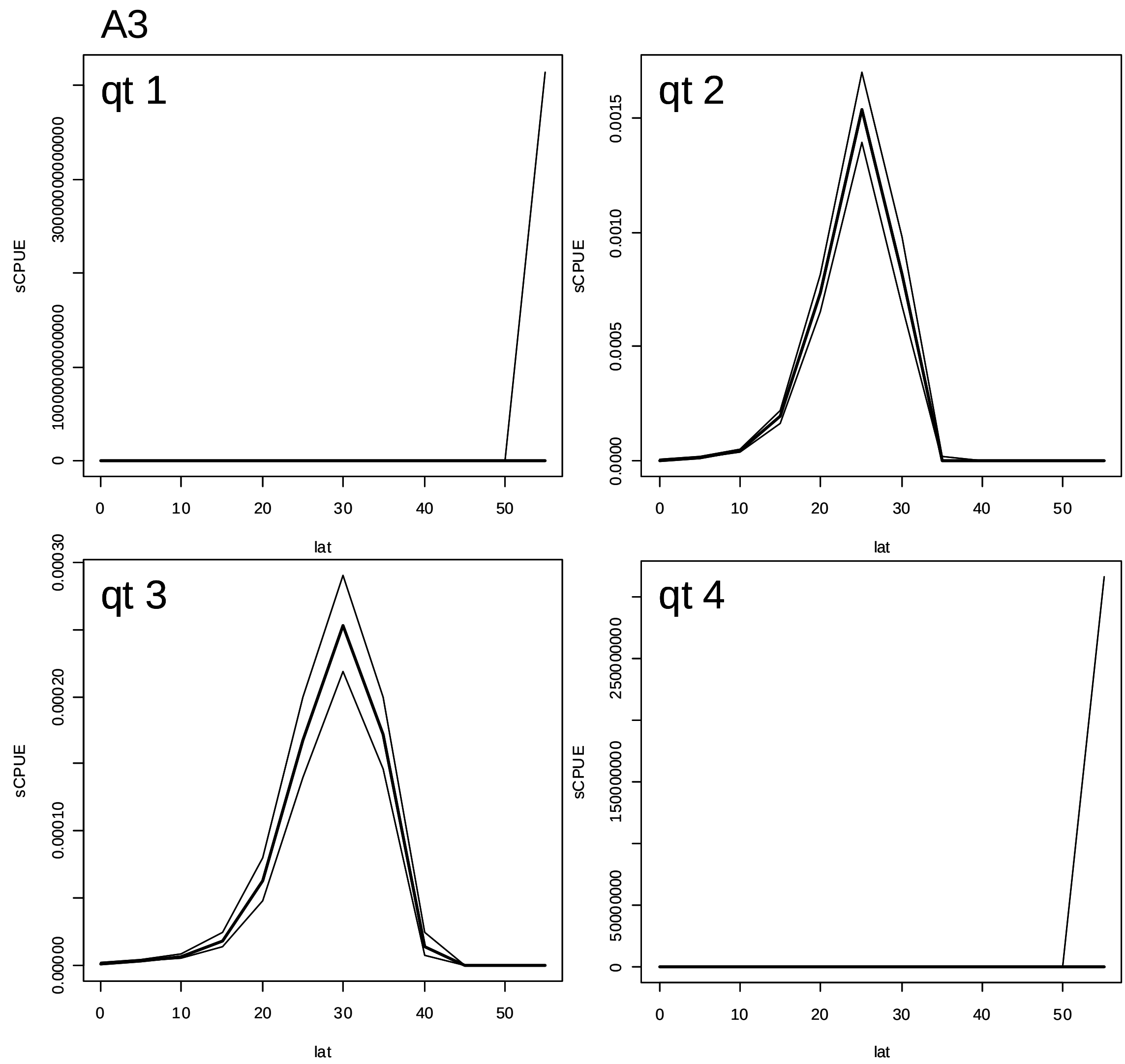

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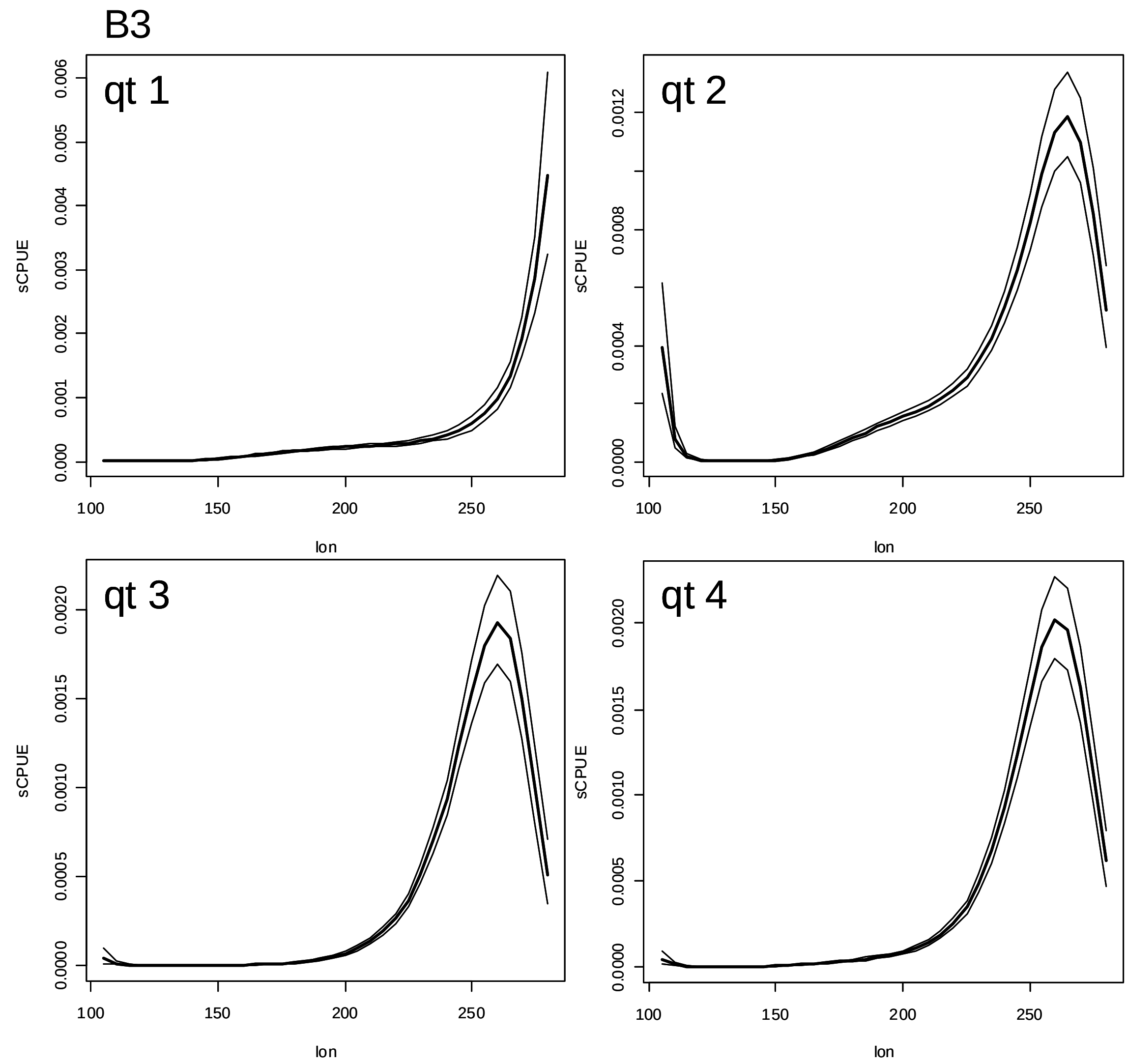

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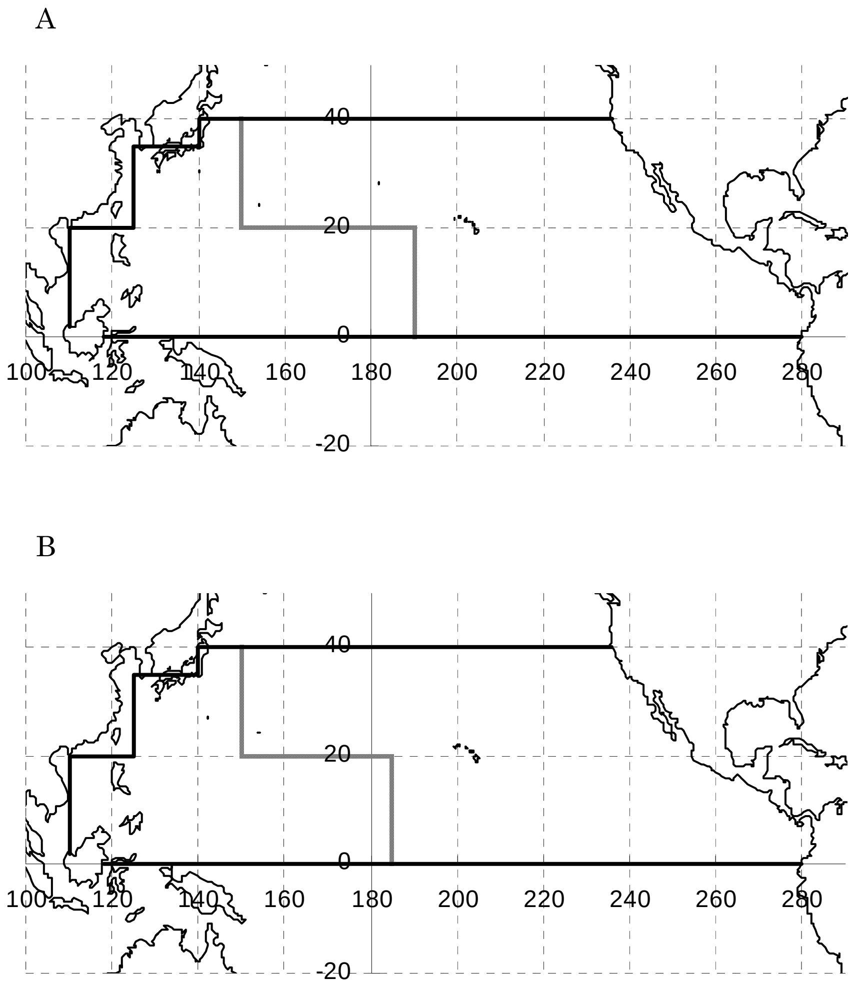

Figure 3

The alternative of separation line for stock structure of striped marlin by GLM analysis of zero catch (A) and positive CPUE (B).

Table 1 Retrospective analysis for zero catch ratio model

year term	lon. of northern separation line	lon. of southern separation line
1975-1976	150	190
1975-1977	150	190
1975-1978	150	190
1975-1979	150	190
1975-1980	150	190
1975-1981	150	190
1976-1981	150	190
1977-1981	150	190
1978-1981	130	175
1979-1981	150	185
1980-1981	150	185

Table 2 Retrospective analysis for positive CPUE model

year term	lon. of northern separation line	lon. of southern separation line
1975-1976	130	185
1975-1977	150	190
1975-1978	150	185
1975-1979	150	185
1975-1980	150	185
1975-1981	150	185
1976-1981	150	180
1977-1981	150	180
1978-1981	130	175
1979-1981	130	175
1980-1981	130	180