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Archiving Blue Marlin harvesting in Japanese coastal fishery

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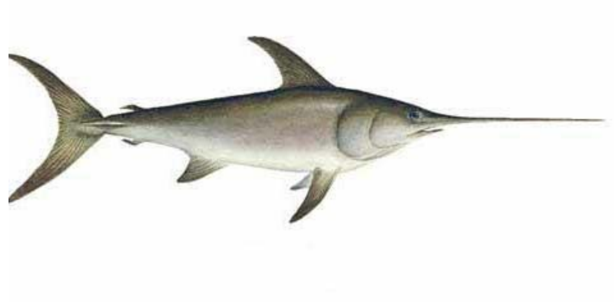

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Archiving Blue marlin harvesting in Japanese coastal fishery

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Introduction

A key fishery dependent data set for fishery stock assessment is time series of commercial harvesting. Although such data do not necessarily reflect the relative/absolute abundance or availability of a fish species in particular fishing grounds, they are an indicator of overall abundance, local availability and fishers' economic incentives in their operations. In general, this data set is an important input for the estimation of abundance in fisheries stock assessments.

Blue marlin (*Makaira nigricas*) is a commercially valuable billfish and also a highly valued game fish for recreational fisheries in the North Pacific(Walsh et al. 2005). Blue marlin is also harvested as bycatch in longline fisheries for tuna species (mainly yellowfin and bigeye tuna). In addition, small artisanal harpoon fisheries occur in the coastal areas of Japan and Taiwan (Kleiber *et al.* 2003; Walsh *et al.* 2005). Incidental harvest also occurs for set net, gill net and trawl fisheries off Japanese coasts, mostly within the Exclusive Economic Zone (EEZ) of Japan.

The amount of research conducted on stock assessments of blue marlin is limited. The blue marlin stock in the Pacific is considered a single stock (Hinton 2001). Hinton (2001) applied the Deriso-Schnute delay difference population model (Quinn, Deriso 1999) to estimate abundance and biological references for the blue marlin stock and reported the current biomass and fishing efforts in the Pacific are healthy and close to the level to maintain the maximum sustainable yield (MSY). However additional data is desired to improve blue marlin stock assessments. Kleiber *at el*. (2003) applied *MULTIFAN-CL*, which is a length-based, age structured, spatially heterogeneous stock analysis model. Their analysis concluded current fishing effort is close to produce MSY, thus confirming Hinton's results.

Their two studies included data from Japanese offshore and distant-water fisheries, but did not take account Japanese 'coastal' fishery of the northwest Pacific, comprised of Japanese coastal longliners of less than 20 metric tonne capacity, costal harpooners, set nets, gill nets and drifting nets. Most of the Japanese coastal fisheries occur within the EEZ of Japan. The current stock assessment of blue marlin is deficient in accumulating the complete time series data of harvesting data from the Japanese coastal fisheries in the northwest Pacific, illustrating the need for appropriate data sets to improve estimation of abundance and biological references toward sustainable fisheries.

The time series data of commercial harvesting for blue marlin by the Japanese coastal fisheries in Northwest Pacific has an archival challenge. The Statistic Department, Ministry of Agriculture, Forestry and Fishery of Japan undertakes the public data management and compiles annual statistics associated with agriculture, forestry and fishery industries in Japan as a year book, "*Norin –tokei*", which is the only available data of the commercial harvesting statistics for billfish fisheries in the Japanese coastal fisheries within the northwest of Pacific since 1952. An archiving challenge of this time series is the aggregation of catch for blue and black marlin (*Makaira indica)* as "blue marlin group", which is the combine of blue marlin and black marlin rather than blue marlin only catch. The differentiation of the time series of catch as discrete species is indispensable task to apply single species stock assessment for blue marlin. The possible method to estimate discrete harvest for blue marlin is to utilize the log-book data of Japanese longline operations, which documented the blue and black marlin harvest independently at the operational level.

The aim of this short report is to explore how to extract discrete catch of blue and black marlin for the Japanese coastal fishery data of the northwest Pacific from *The Statistics of Agriculture, Forestry and Fishery of Japan (Norin –tokei).* To do so, this report presents time series of the spatial distributions of the catch proportion of blue marlin in the total catch of blue marlin group (the sum of blue and black marlin) which is estimated from the log-book records of Japanese offshore and distant-water longliners in the northwest Pacific.

Data

As the first step, the log-book for the period between 1970 and 1993 for Japanese offshore and distant-water longliners is used to visualize variations in the time series of the spatially distributed proportion of the catch for blue and black marlin by the fisheries. The information of this log-book data includes time and location information and discrete catch weights of blue and black marlin by offshore and distant-water longliners. The total data set for the northwest Pacific for the log-book record is 52,979. The log-book data of offshore and distant-water longliners does not fully cover all operations of the Japanese longliners. The log-book recording system for Japanese coastal longliners only started in 1994 and represents unfortunately limited coverage, making it difficult to apply the long time series for *Norin-tokei* (from 1952).

Method

The strategy to analyze Catch per Unit Effort (CPUE) is applied. First, spatial resolution for aggregated data is set and the grid cells of each 10 degree latitude and 10 degree longitude in the Northwest Pacific (latitude more and equal to 0 and longitude less and equal to 180 W) are defined. Then, the log-book data were associated with the grid cells. Secondly, the data were aggregated as 1) four seasons (Season 1/from January to March, Season 2/from April to June, Season 3/from July to September and Season 4/from October to December) and 2) five-year time periods (Time series 1, 1971-1975, Time series 2, 1976-1980, Time series 3, 1981-1985, Time series 4, 1986-1990 and Time series 5,1991-1993). Kleiber *et al.* (2003) reported that the catchability of the blue marlin indicates the seasonal pattern of variation, and this confirmed the rationality to apply seasonal aggregations.

The proportion of catch weight of blue marlin is calculated for each spatial grid cell, season and the five-years time period as defined above as;

$$\theta_{blue} = \frac{\omega_{blue}}{\omega_{blue} + \omega_{black}}$$

θ_{blue}: $proportion\ for\ Blue\ marlin\ (0 \leq \theta_{blue} \leq 1)$
ω_{blue}: $harvest\ weight\ of\ Blue\ marlin$
ω_{black}: $harvest\ weight\ of\ Balck\ marlin$

The 95 % confidence interval of the proportion is calculated for each grid cell with ten or more logbook data. The general formula of confidence interval is;

$$\theta_{blue} + z\sigma_{\theta_{blue}}$$

Where z is a constant and depends on the level of given confidence intervals (95% for this study) and $\sigma_{\theta_{blue}}$ is the standard error of θ_{blue} which calculated as

$$\sigma_{\theta_{blue}} = \sqrt{\frac{\theta_{blue}(1 - \theta_{blue})}{n}}$$

n: $data\ size$

Data size (*n*) represents the number of data in each grid cell, defined by given spatial grid cells, season and 5 years time period, recorded in the log-book.

Result

Fig.1 is a summary of the northwest Pacific data in the log-book record. The average total catch of black marlin between 1971- 1993 (Fig.1 a) was 53,434 metric tonnes per season. The temporal pattern of the black marlin catch shows a constant diminished trend over 23 years. For example, the annual catch of the black marlin (i.e., the sum of four seasons) was 446,388 metric tonnes in 1971, but only 48,504 metric tonnes in 1993. The average total catch of black marlin between 1971- 1993 (Fig.1 b) was 723,768 metric tonnes per season. The temporal pattern of the black marlin catch exhibits spectacular variability in all seasons and over 23 years, with the average catch being 723,768 metric tonnes per season and its' standard deviation being 293,745 metric tonnes. This reduced catch in black marlin and the constant catch in blue marlin results in an increased pattern in terms of the proportion of the blue marlin catch in relation to the total combined catch of black and blue marlin. The annual average proportion of the blue marlin catch is 0.89 in 1971 and 0.98 in 1993.

The spatial patterns of the estimated average proportion of blue marlin catch for 10 degree longitude and 10 degree latitude grid cells (Fig 2) shows variations in the 1970s, but in most of the years after the 1980s (with the exception of 1986-1990 and season 4) a proportion over 0.95 dominates. The average proportion of blue marlin tends to vary at longitudes between 100-120 degrees. This would be the result of the limited number of data pertaining to this region.

The time series of the estimated average and the 95% confidence interval for the proportion of the blue marlin catch (Fig. 3 a) suggests an increased trend for most of the grid cells for which enough data are available. At the -2.5 latitude (Fig.3 b-5), seasonal patterns are noticed for most of the grid cells: decreased proportions between season 2 and 3, and increased proportions in season 4. This would reflect the seasonal migration of black and (or) blue marlin.

Discussion

The increasing in proportion of the blue marlin catch, in terms of the total catch of the northwest Pacific, is the result of the reduction in the black marlin catch rather than an increase in the blue marlin catch. The dominated blue marlin catch in relation to the total catch makes the proportion of blue marlin similar to those of past decades close to one. Since the distribution of the proportion is not a continuous distribution, this data would induce bias in the estimations for the confidence interval. Therefore, the application of the confidence interval, as it is used to interpret the blue marlin catch in "*Norin-Tokei*", needs to be considered.

The spatial pattern of the proportions is the result of a compound of fishery operators' economic incentives and the local abundance of blue and black marlin. Despite these potential biases, the seasonality of the catch proportion in low latitudes suggests that further analysis of this data set may contribute to our understanding of the behavior of blue and black marlin biology.

Further analysis of the heterogeneous economic incentives of fishery operators in the black and blue marlin catch (e.g., the development of the relative market price, expected availability by operators) would add further depth and precision to this study.

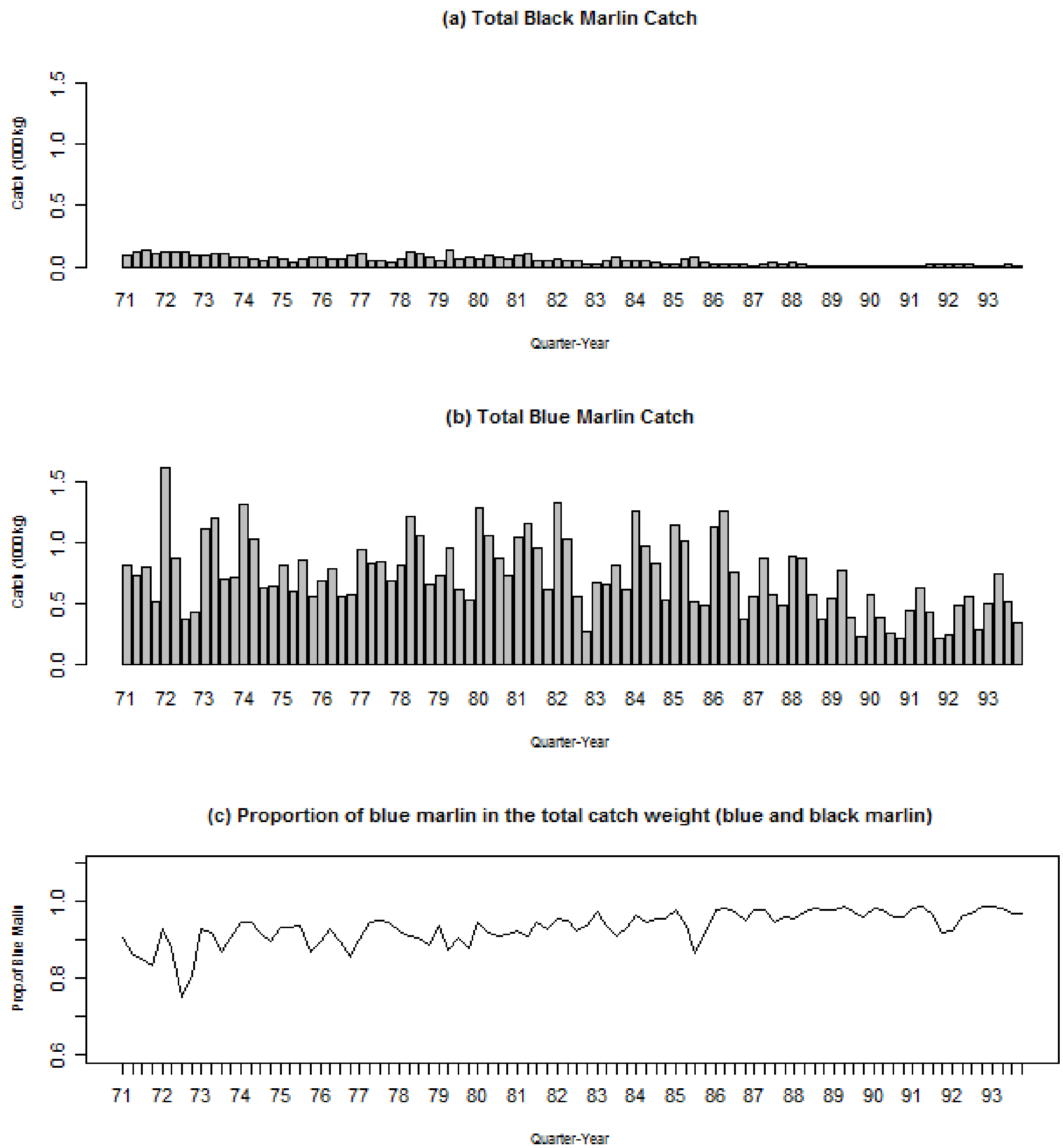


Figure 1: Summary of catch data within the northwest Pacific from the log-book of Japanese off-shore and distant water fisheries.

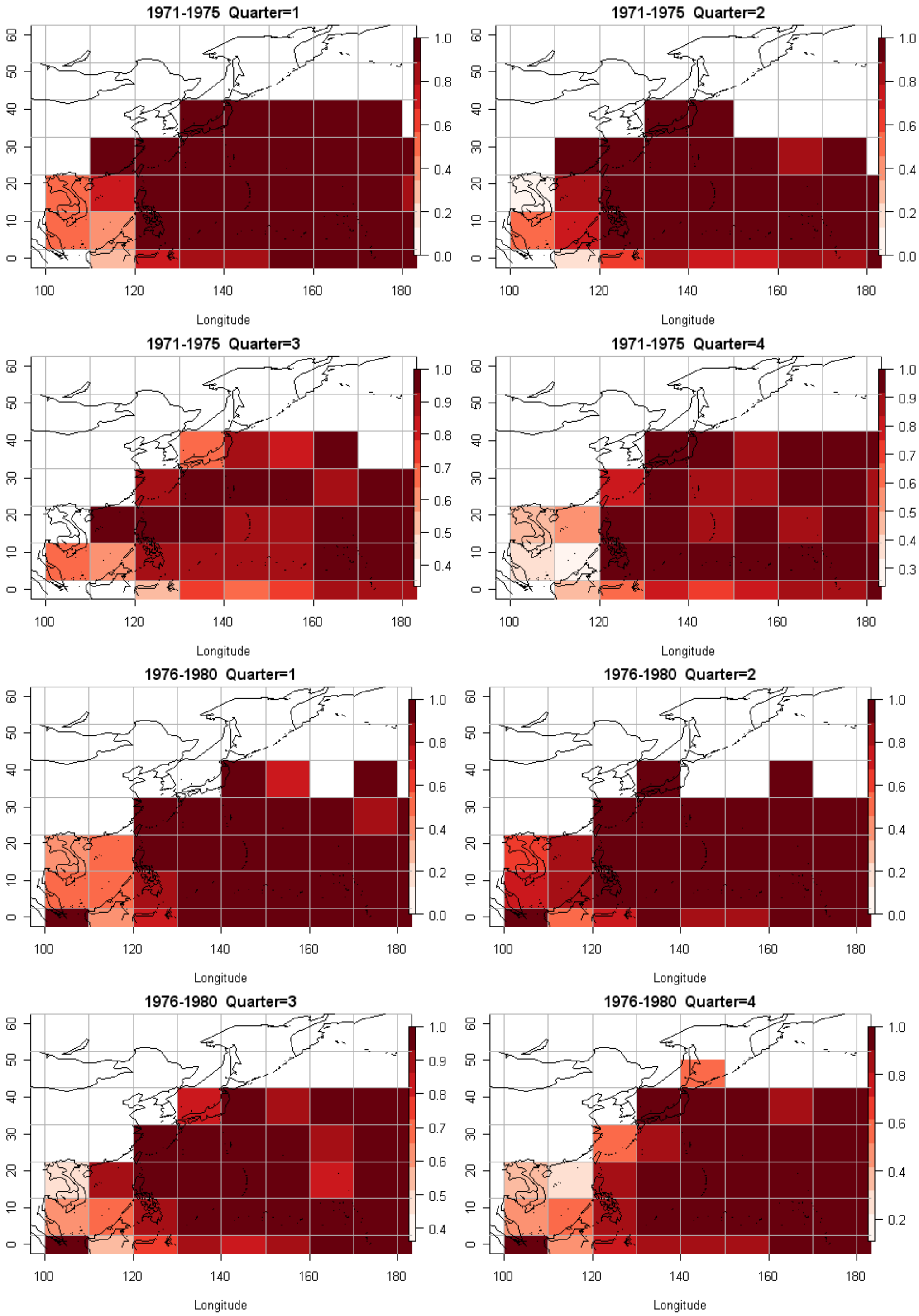
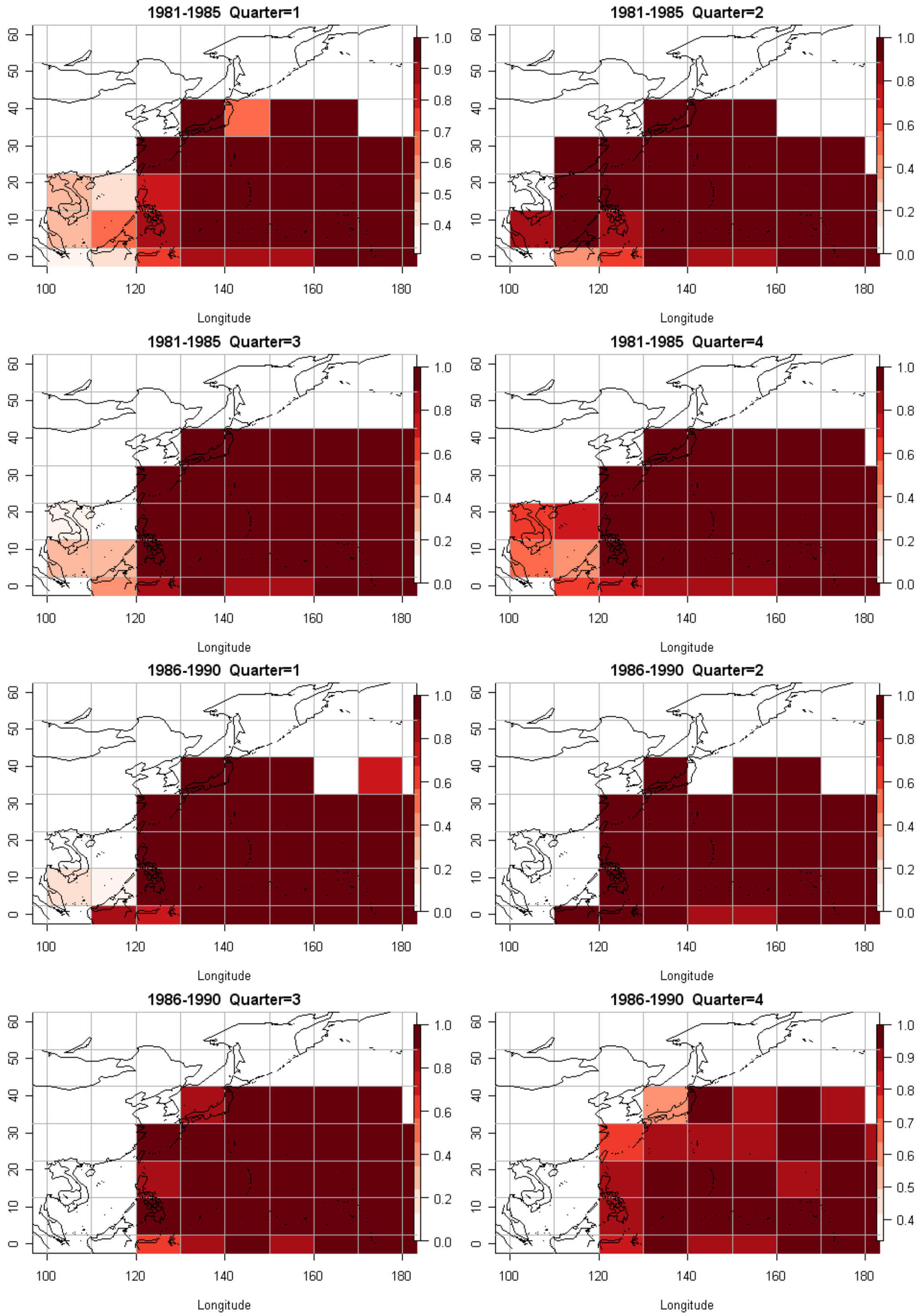


Figure 2: Distribution of the estimated average proportion of the blue marlin catch in relation to the total black and blue marlin catch in the northwest Pacific the western Pacific from the log-book of Japanese off-shore and distant water fisheries (for 10 by 10 degree resolutions and for averages over 5 years, with the exception of 1990-93).



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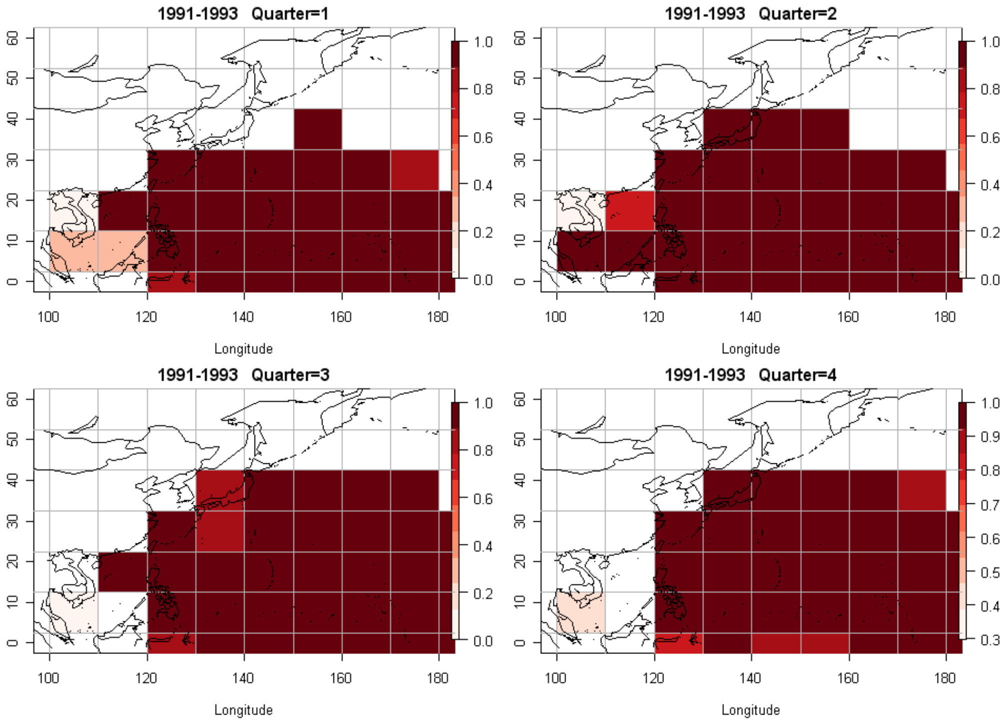

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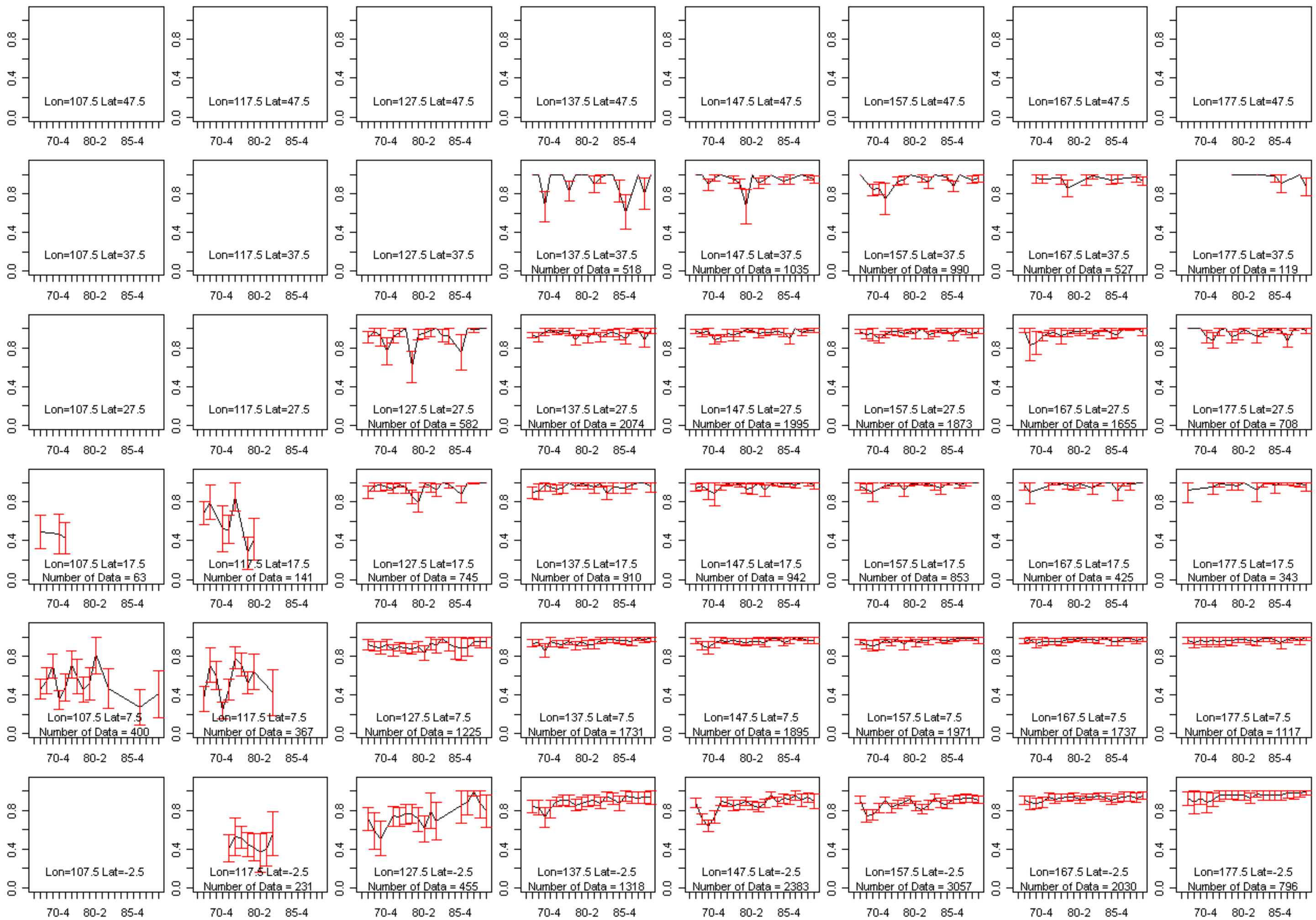

Figure 3: (a) Distribution of time series of the estimated average proportion and the 95% confidence intervals of blue marlin in relation to the total weight of black and blue marlin for the northwest Pacific the western Pacific from the log-book of Japanese off-shore and distant water fisheries (for 10 * 10 degrees, and averages over 5 years, with the exception of 1990-1993). X-axis shows the time series and y axis shows the proportion.

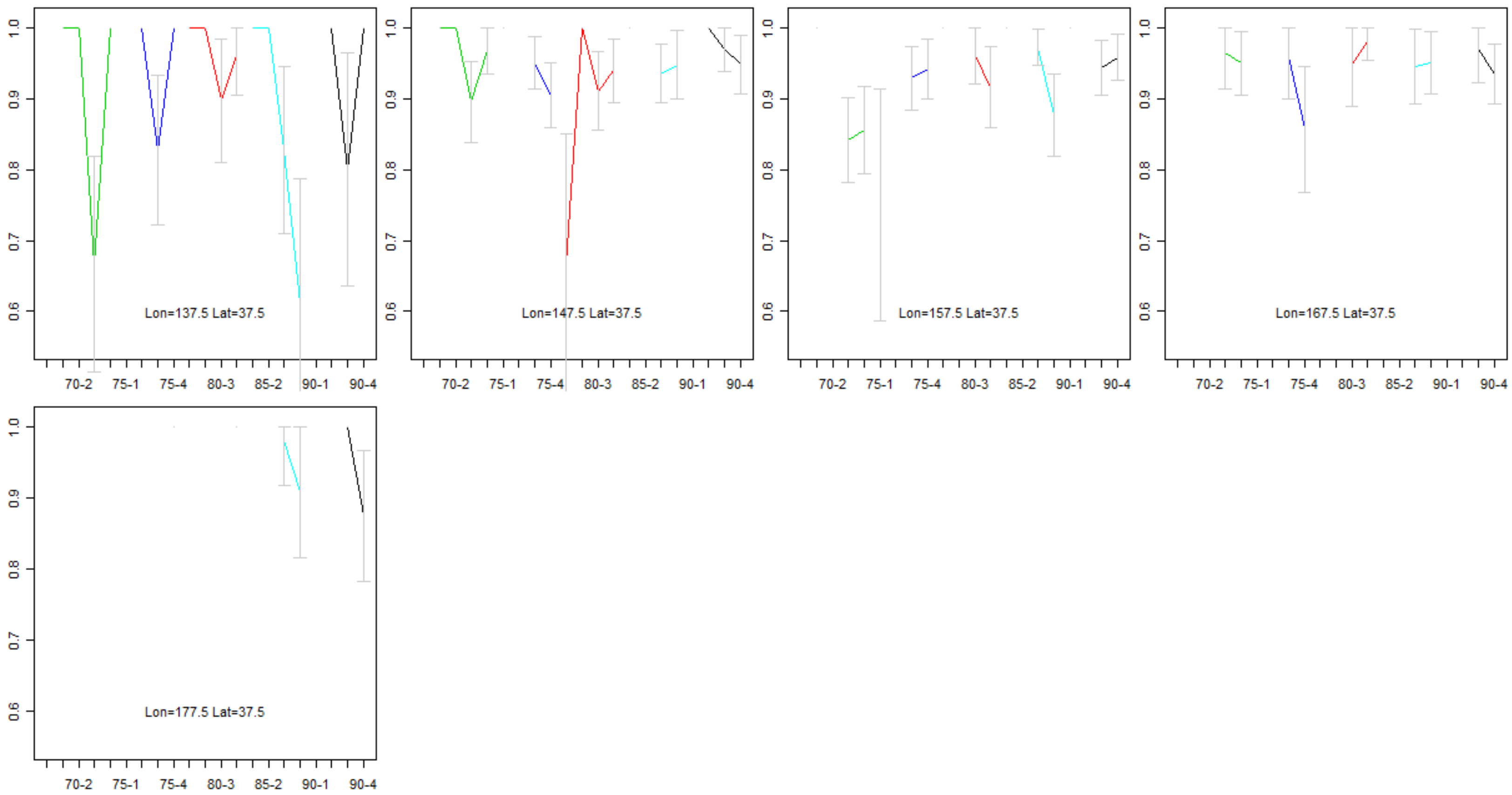

Figure 3 (b-1/latitude=37.5): Seasonality of the estimated average and the 95% confidence intervals of blue marlin in relation to the total weight of black and blue marlin for the northwest Pacific the western Pacific from the log-book of Japanese off-shore and distant water fisheries (selected for 10 * 10 degree cells, and for 5-years averages). Each line segment represents the average for the following 5-year periods: green (1971-1975), blue (1976-1980), red (1981-1985), sky blue (1986-1990), and black (1991-1993).

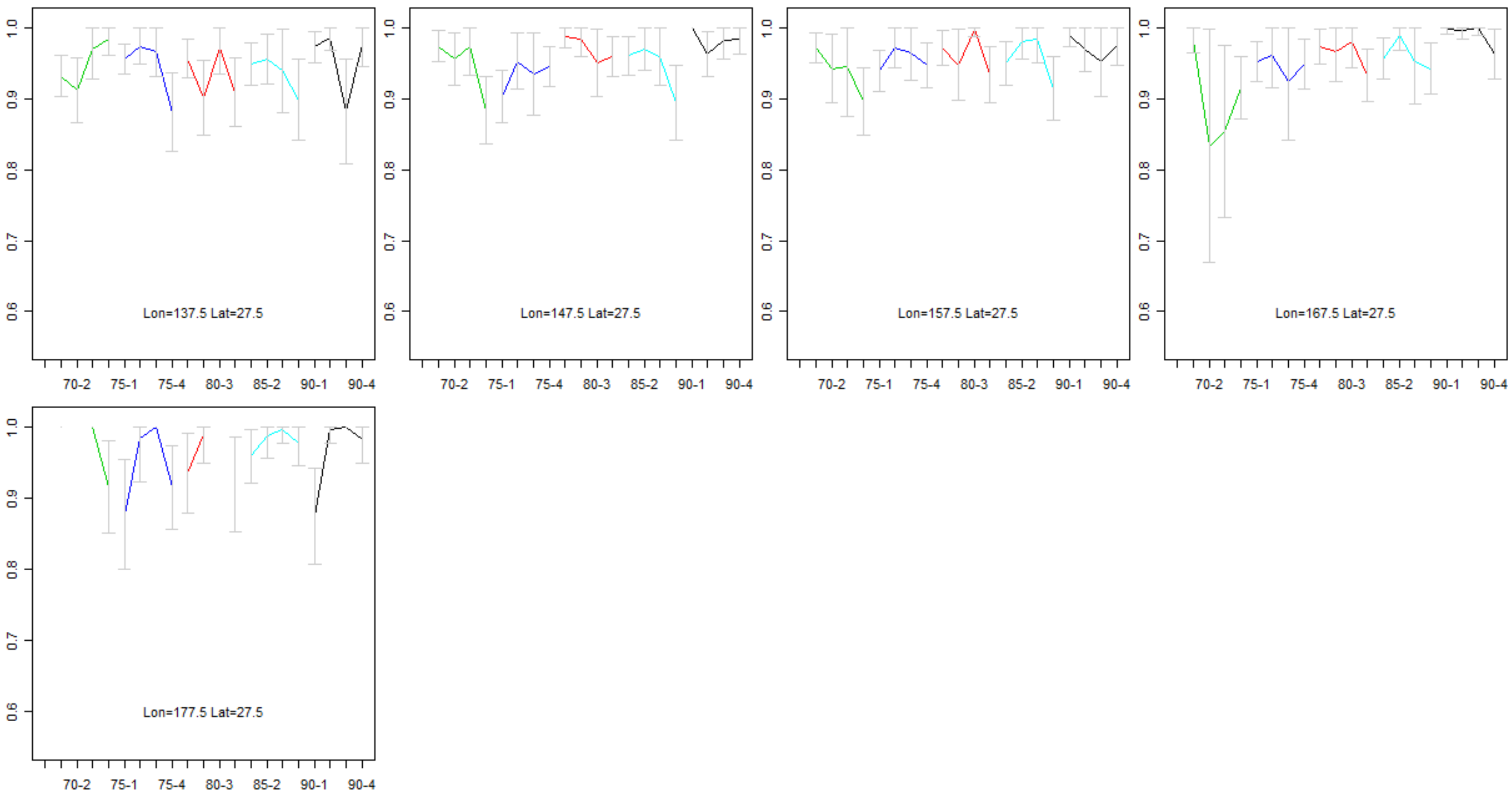

Figure 3 (b-2/latitude=27.5): Seasonality of the estimated average and the 95% confidence intervals of blue marlin in relation to the total weight of black and blue marlin for the northwest Pacific the western Pacific from the log-book of Japanese off-shore and distant water fisheries (selected 10 * 10 degree cells, and 5-year averages). Each line segment represents the average for the following 5-year periods; green (1971-1975), blue (1976-1980), red (1981-1985), sky blue(1986-1990), and black (1991-1993).

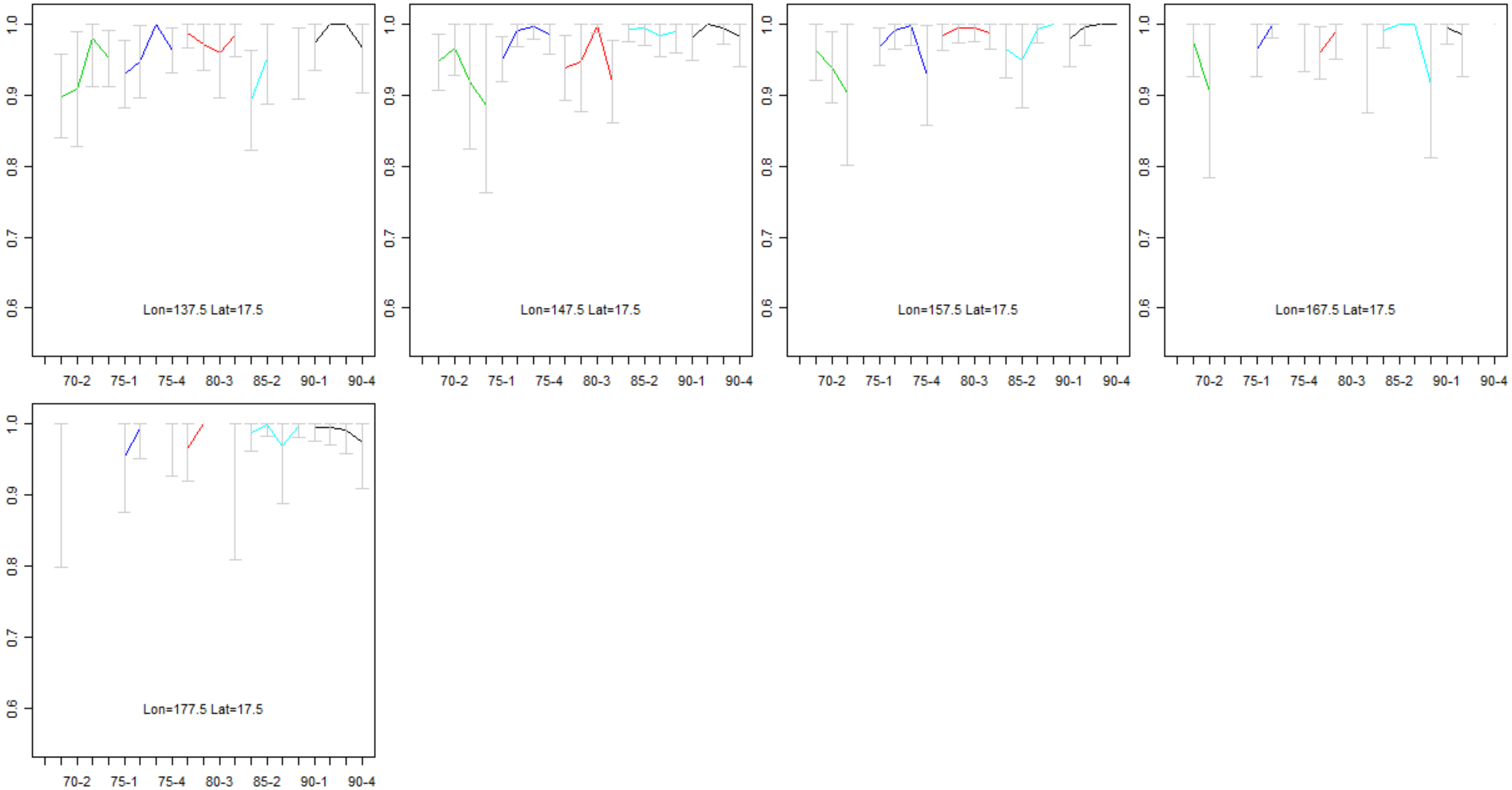

Figure 3 (b-3/latitude=17.5): Seasonality of the estimated average and the 95% confidence intervals of blue marlin in relation to the total weight of black and blue marlin for the northwest Pacific the western Pacific from the log-book of Japanese off-shore and distant water fisheries (selected for 10 * 10 degree cells, and for 5 years averages). Each line segment represents the average for the following 5-years periods: green (1971-1975), blue (1976-1980), red (1981-1985), sky blue (1986-1990), and black (1991-1993).

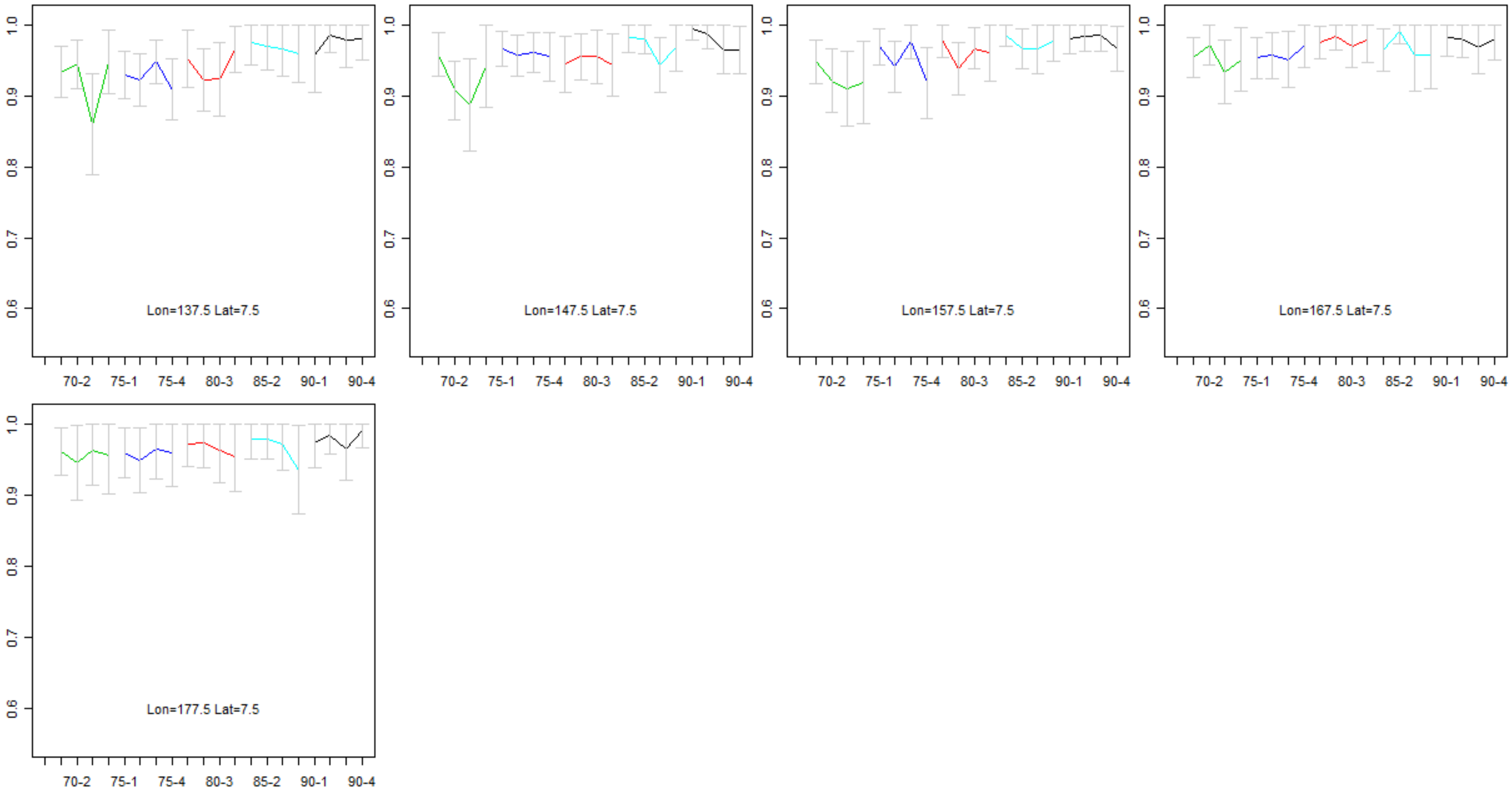

Figure 3 (b-4/latitude=7.5): Seasonality of the estimated average and the 95% confidence intervals of blue marlin in relation to the total weight of black and blue marlin for the northwest Pacific the western Pacific from the log-book of Japanese off-shore and distant water fisheries (selected for 10 * 10 degree cells, and for 5-years averages). Each line segment represents the average for the following 5-years periods: green (1971-1975), blue (1976-1980), red (1981-1985), sky blue (1986-1990), and black (1991-1993).

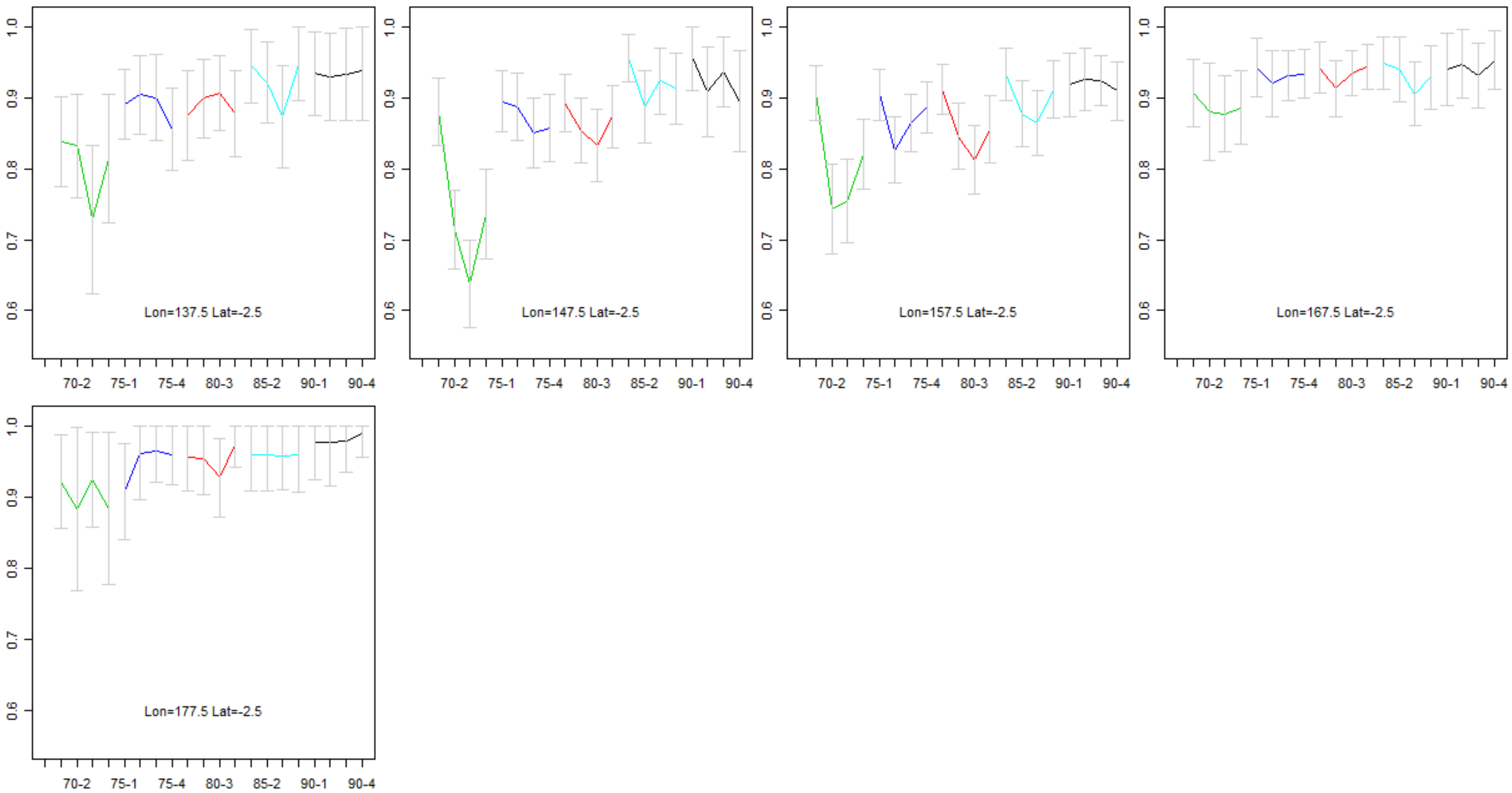

Figure 3 (b-5/latitude=-2.5): Seasonality of the estimated average and the 95% confidence intervals of blue marlin in relation to the total weight of black and blue marlin for the northwest Pacific the western Pacific from the log-book of Japanese off-shore and distant water fisheries (selected for 10 * 10 degree cells, and for 5-years averages). Each line segments represents the average for the following 5-year periods; green (1971-1975), blue (1976-1980), red (1981-1985), sky blue (1986-1990), and black (1991-1993).

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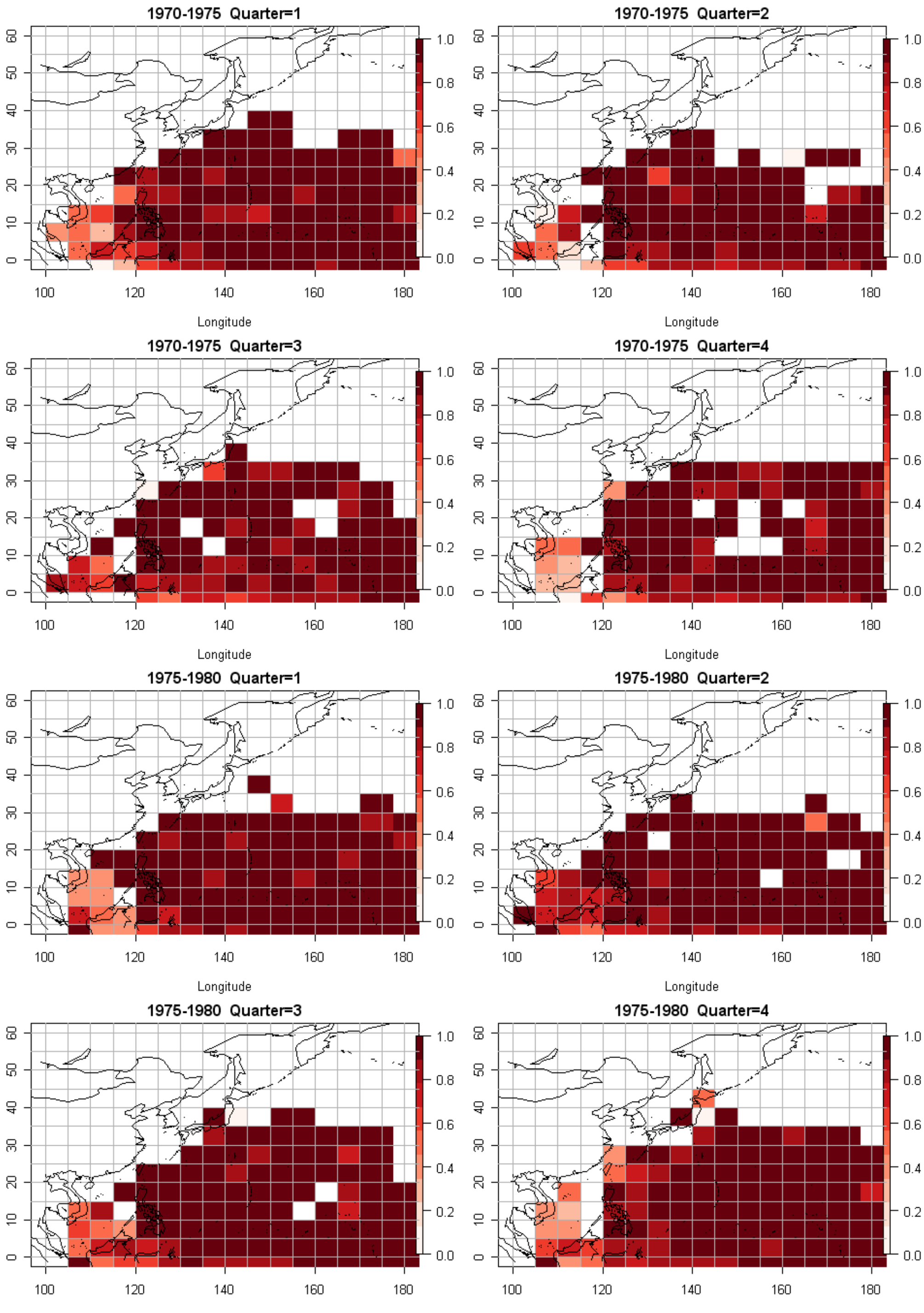
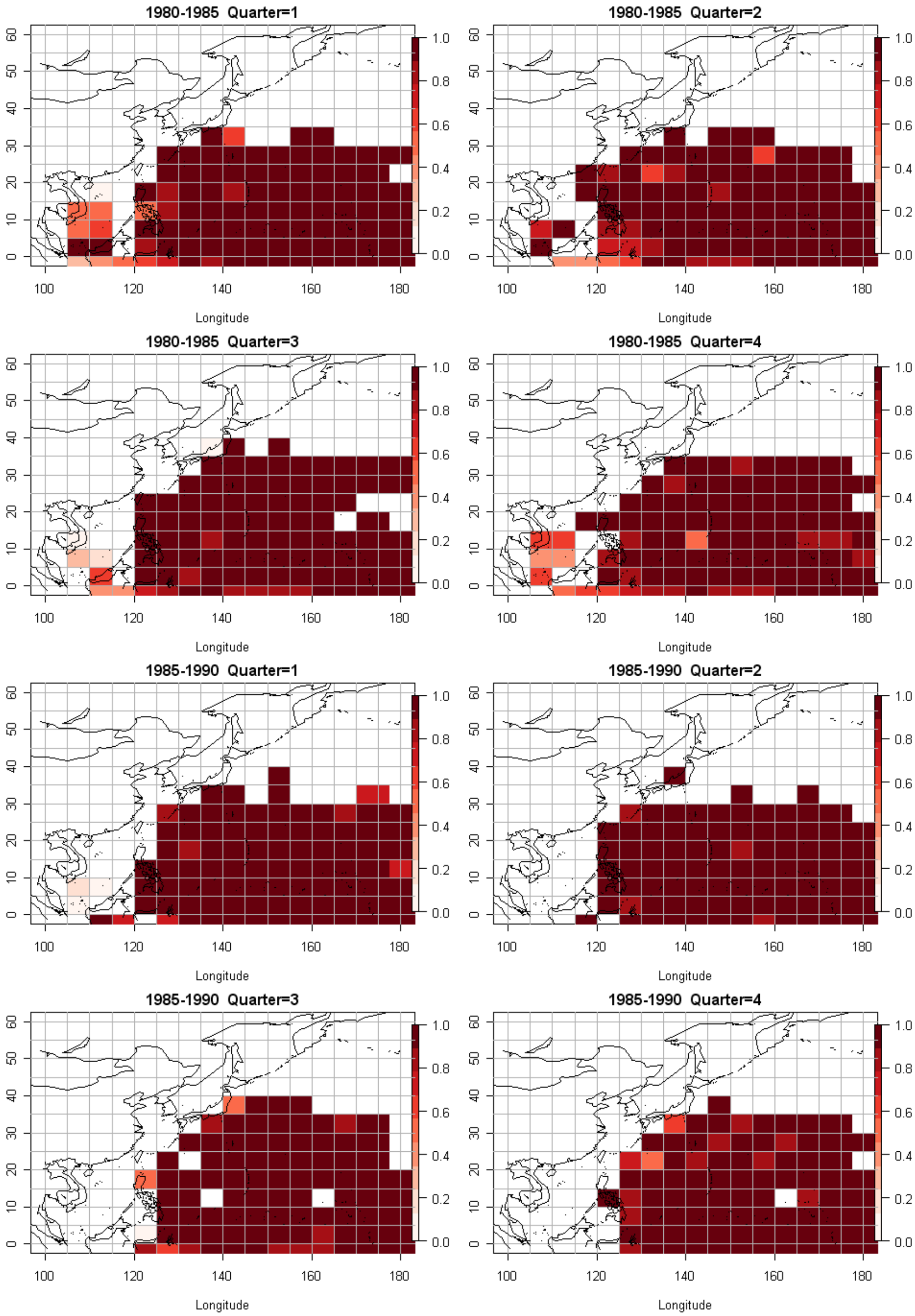
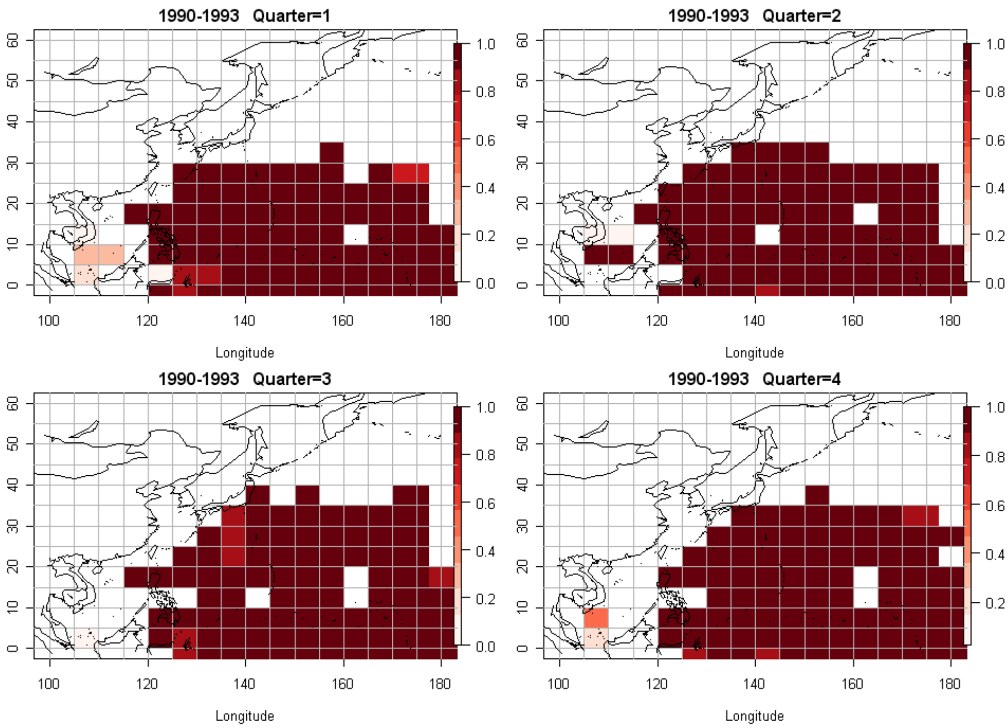
Appendix 1

Distribution of the estimated average proportion of the blue marlin catch inn relation to the total catch of black and blue marlin in the northwest Pacific the western Pacific from the log-book of Japanese off-shore and distant water fisheries (representing 5 by 5 degree resolutions and the average over 5-year periods, with the exception of 1990-93).





Appendix 1 continued.



Appendix 1 continued.

Appendix 2: Coverage of the time series of the average proportion of blue marlin in relation to the total weight of black and blue marlin (5 * 5 degrees) Longitude 105 -185 (from left to right) and latitude 0-50 (from bottom to top). X-axis shows the time series and y axis shows the proportion.