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SPATIAL SIZE DATA STRATIFICATION FOR LENGTH-BASED STOCK ASSESSMENTS

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Simon D. Hoyle¹ and Adam D. Langley²

¹ Oceanic Fisheries Programme, SPC.

² Consultant to Oceanic Fisheries Programme, SPC

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Introduction

Length data from the Japanese distant-water and offshore longline fleets are available aggregated in spatial strata of 10 degrees of latitude by 20 degrees of longitude, and more recently 5 degrees by 10 degrees (Figure 1). In previous yellowfin assessments, quarterly length frequency distributions were derived for the principal longline fisheries weighted by the spatial distribution of the quarterly catch from the individual fishery. However, there is considerable spatial variation in the sizes of longline-caught yellowfin and bigeye tuna within individual regions of WCPO stock assessments. There have also been large shifts through time in the spatial distribution of both longline catch and size sampling. These changes have influenced the composite regional-specific length compositions. Length sample locations aggregated by decade for yellowfin tuna are illustrated in Figure 1. Locations are even more variable at the year-quarter scale used in stock assessments, but it is the long-term shifts in sample locations that have the greatest effects on stock assessment outcomes (Harley *et al.* 2010).

For the current 2011 bigeye and yellowfin assessments, a new approach was applied to re-stratify the size frequency data according to our best estimate of the distribution of the population, to reduce the influence of spatial changes in the distribution of catch and sample collection. The objective of this approach was to generate size frequency distributions that were more consistent with the underlying size distribution of the population within a region (mediated by the long-term average selectivity of the fishery).

This change was necessary because in a catch at length model such as MULTIFAN-CL (Fournier *et al.* 1998), the predicted catch is removed rather than the observed catch. According to the separability assumption used in MULTIFAN-CL, the length distribution of the catch is a function of the population length distribution and the selectivity. i.e. $F_{l,t} = s_l F_t$, and therefore $C_{l,t} = s_l F_t N_{l,t}$ (Quinn & Deriso 1999). Selectivity does not change from year to year in the model, so the model interprets changing observed lengths as changing population lengths. If length distributions change due to fleet movements coupled with spatial variation in fish sizes, rather than population length changes, the model results will be affected and potentially biased, depending on the relative weighting assigned to the size data.

Methods

The following procedure was applied to generate an aggregated year/quarter length composition for a specific region longline fishery from the Japanese length frequency data.

- i. In order to define the average long-term spatial distribution of the population, the average standardised CPUE (number of fish per 100 hooks) for the Japanese longline fishery during 1960-

1986 was determined for each of the 10*20 lat/long stratum that comprises a region (typically 6-9 cells per region). The CPUE's were derived from the analysis used for regional weighting (Hoyle 2010) (Figure 2 and Figure 3). The CPUEs were applied to determine the relative weighting of the size data in each cell. A maximum sample size was set at 1000 fish and the strata were assigned an individual sample size relative to the average long-term CPUE of the strata. The individual sample sizes for all strata sum to 1000.

ii. The year/quarter samples (length measurements) from each 10*20 lat/long stratum were scaled to represent the individual sample size associated with the cell.

iii. The rescaled numbers of fish (in each length interval) sampled from each stratum were combined, thereby weighting the samples by the relative abundance of fish in each stratum.

Results

These protocols resulted in samples from strata with a higher abundance of fish having more influence in the composite length composition. Conversely, in year/quarter where samples were only available from strata with lower abundance, a composite length composition was generated, although the overall sample size was lower giving the individual length composition a lower influence on the model.

For yellowfin, the new approach enabled a larger proportion of the length samples to be retained within the model data set, compared to the previous approach where quarterly length samples from a region were excluded if insufficient length samples were available from the strata in that region where most of the catch was taken (Langley *et al.* 2009). For example, in previous yellowfin assessments virtually all length samples collected from LL ALL 1 and LL ALL 2 from 1970 onwards were excluded from the model data set (Figure 4) (Langley *et al.* 2009). In the current formulation, these data are retained but are assigned a lower effective sample size as most of the more recent samples were collected from areas within the regions that have a lower abundance of yellowfin.

For bigeye tuna, fewer samples were retained than in the previous approach. The effect of reweighting the data is illustrated via a comparison with data that had not been adjusted (Figure 5). Variability was reduced (e.g. region 1), samples were removed when the distribution of available data was not representative of the population distribution (region 6), and bias was removed where there were strong shifts in sample location (e.g. region 3). Residuals from the stock assessment show a more consistent size trend through time (Figure 6), although they do indicate lack of fit, probably due to conflict between the size data and the CPUE data.

Discussion

This new method for stratifying size data spatially, according to the size distribution of the population, should result in input data that are more representative of the population dynamics. It should therefore reduce conflict between the data inputs into a model and result in more reliable stock assessments. Size data are very influential in catch at length models. The method has been used to prepare length and weight data for the principal longline fisheries in the 2011 bigeye and yellowfin stock assessments (Davies *et al.* 2011, Langley *et al.* 2011).

Size data have traditionally been reweighted to match the size distribution of the catch. This is the appropriate method for Virtual Population Analysis, in which the catch at age is removed from the population, and the separability assumption is not applied. With catch at length models such as MULTIFAN-CL, however, constant selectivity is assumed and predicted catch is removed.

Ideally, the size distribution should be spatially uniform across a MULTIFAN-CL fishery. However, this is rarely the case and there are spatial size variation and size trends evident for bigeye, yellowfin and skipjack tuna (SPC unpublished data). Defining smaller fisheries in which sizes are uniform may be a viable alternative, but stratification across space seems a more practical approach at this time.

Acknowledgements

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References

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Figures

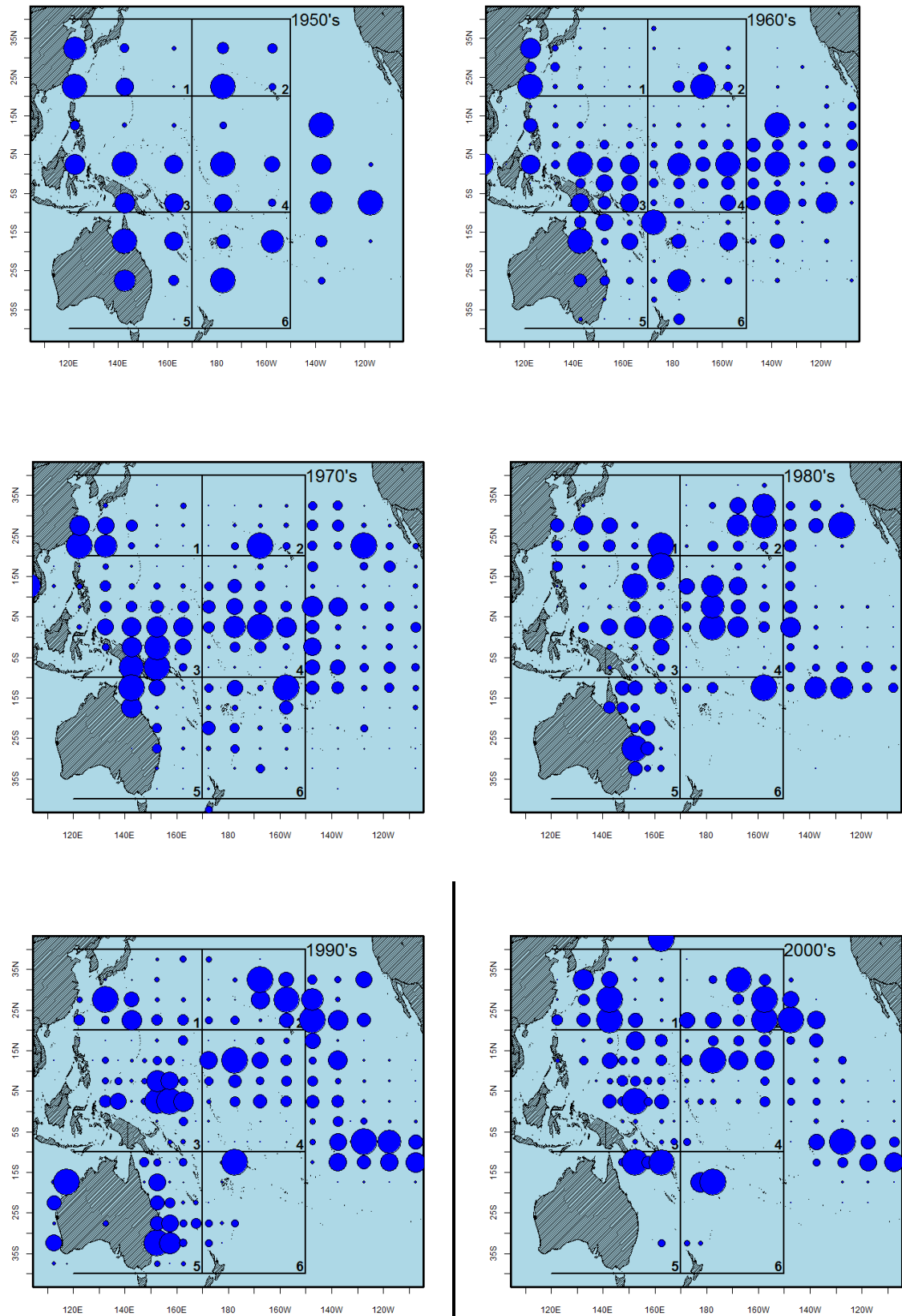


Figure 1: Maps of Japanese longline length sample locations by decade, for yellowfin tuna. The area of the circle is proportional to the number of samples within a region. Circle sizes are not proportional between regions.

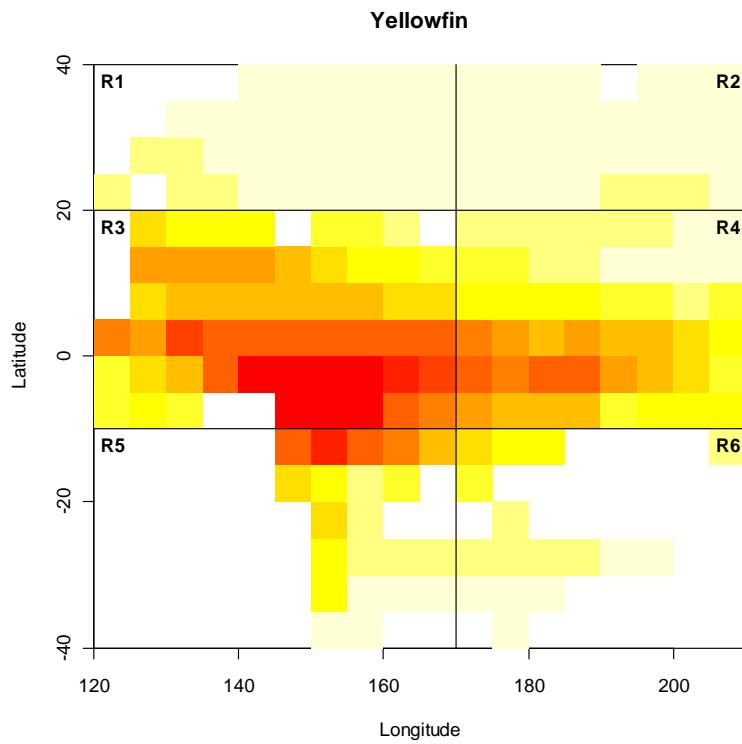


Figure 2: Average long-term (1960-1987) spatial distribution of yellowfin tuna CPUE. Darker colours represent higher CPUE.

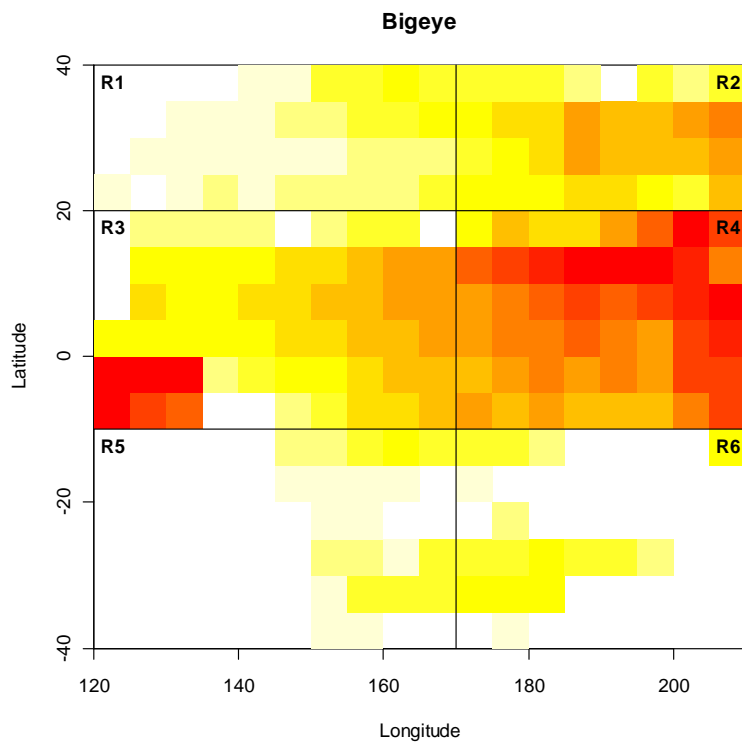


Figure 3: Average long-term (1960-1987) spatial distribution of bigeye tuna CPUE. Darker colours represent higher CPUE.

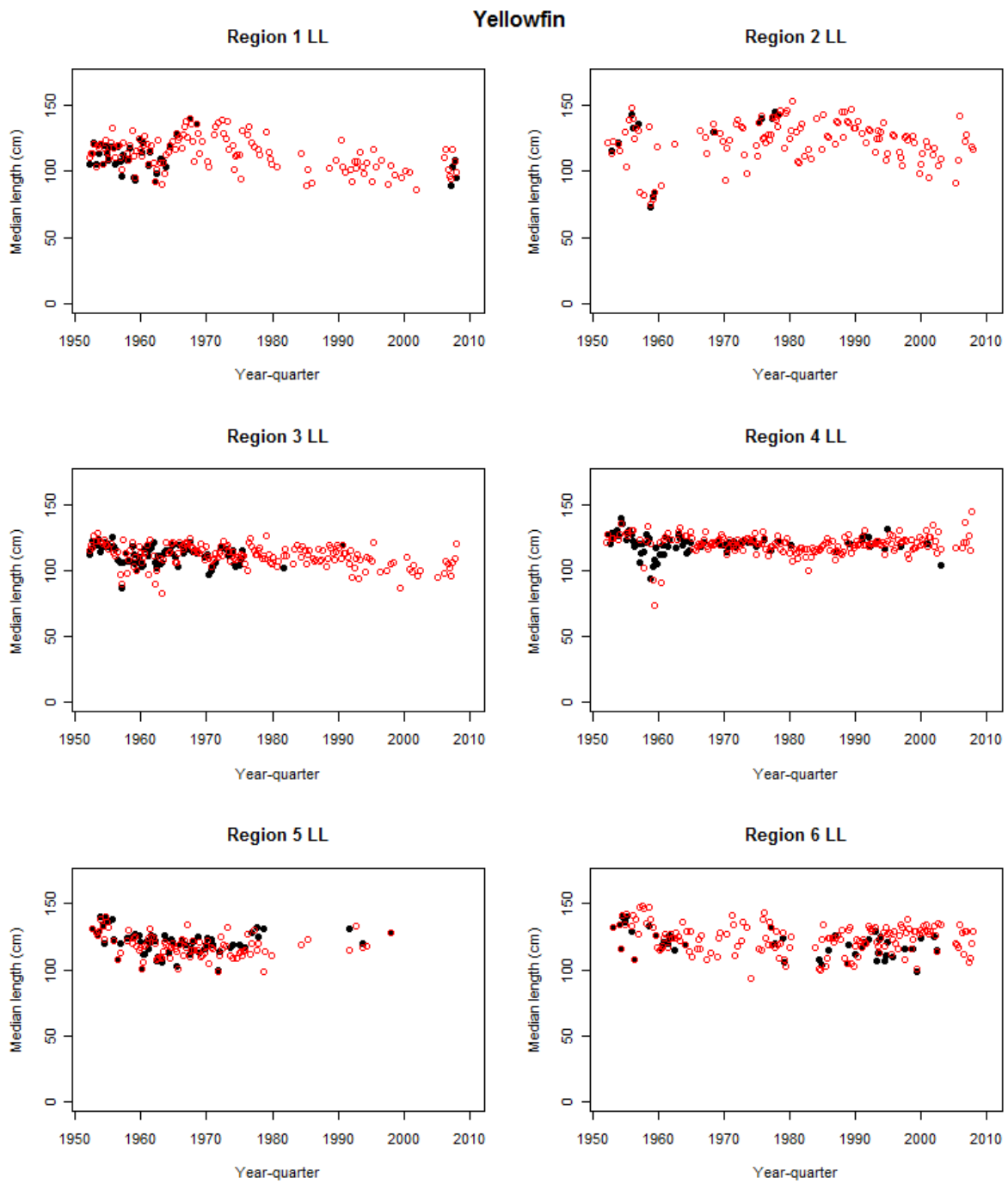


Figure 4: Median quarterly lengths for Japanese longline yellowfin tuna samples a) adjusted according to the distribution of the catch, in the 2009 stock assessment (black) vs b) reweighted spatially as used in the 2011 stock assessment (red).

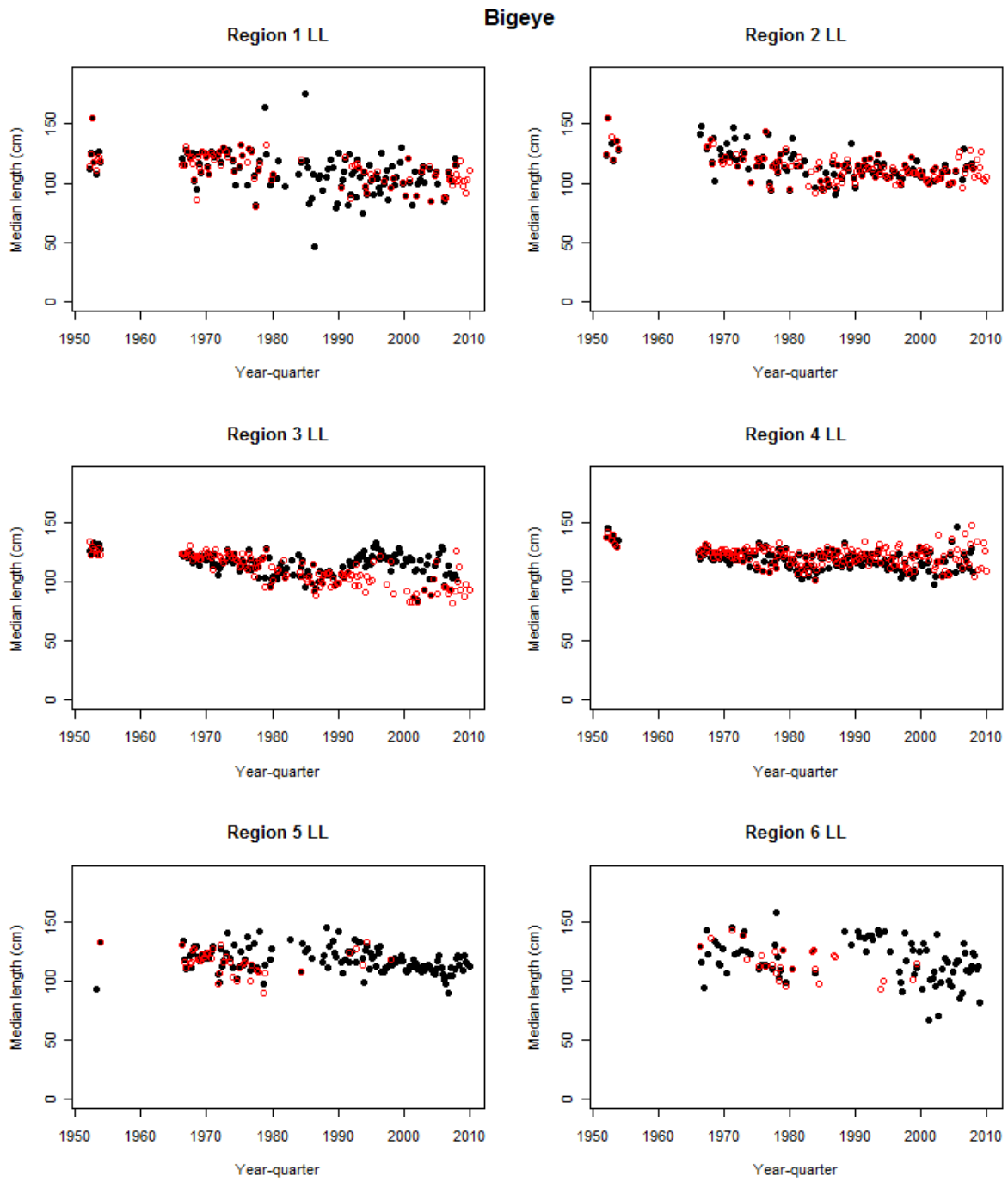


Figure 5: Median quarterly lengths from the 2010 bigeye assessment, without reweighting (black), and after spatial reweighting of length samples as used in the 2011 stock assessment (red).

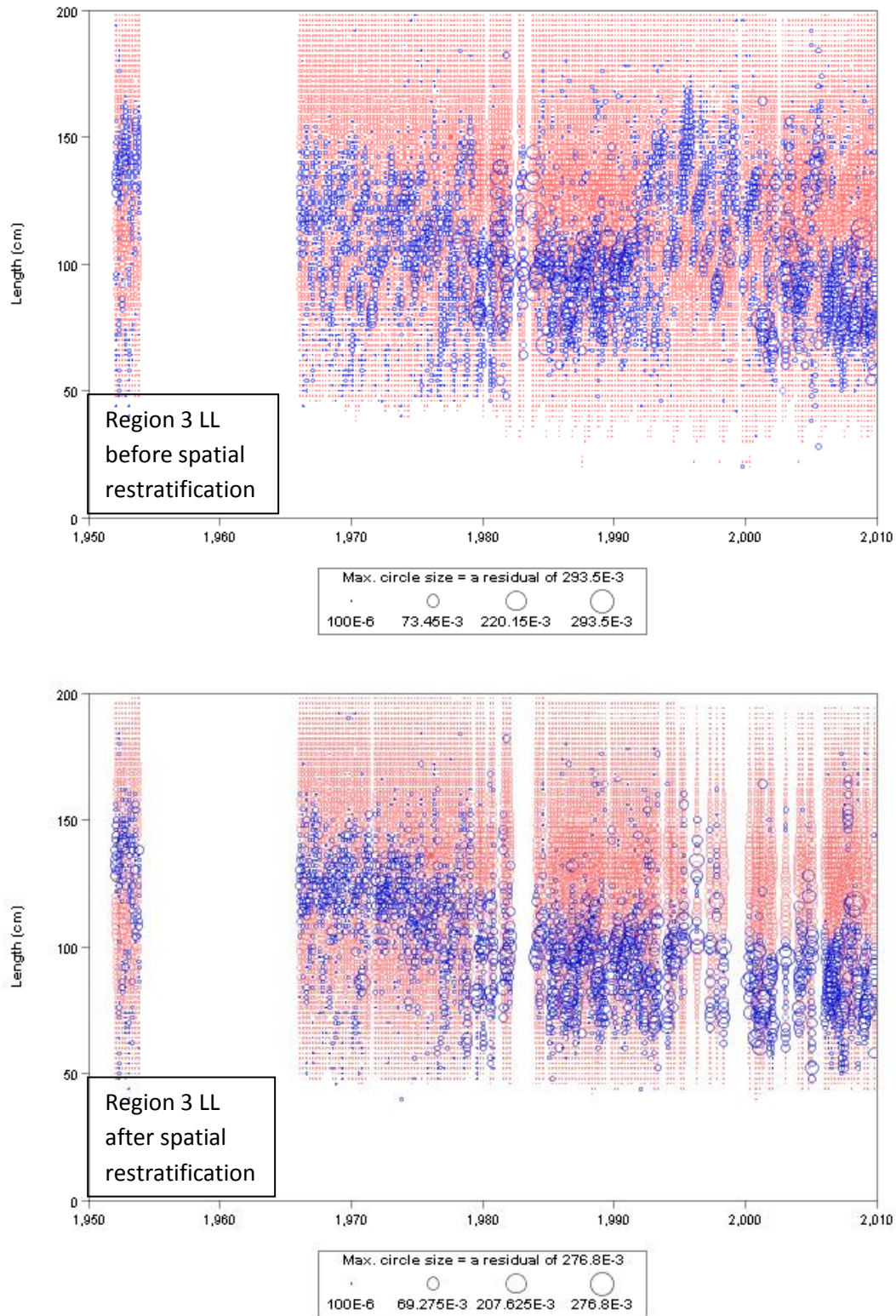


Figure 6: Residuals from 2011 bigeye stock assessment indicating fit to the Japanese longline length data in Region 3 (fishery 4), before (top) and after (bottom) spatial restratification of the data.