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CATCH-AT-SIZE AND AGE ANALYSES FOR ATLANTIC BIGEYE

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SUMMARY

This document presents an analysis of the length frequency data (i.e. catch-at-size, CAS) for Atlantic bigeye. Two main methods are used, i.e. Powell-Wetherall plots to explore changes in Z based on length data and catch curve analysis using catch-at-age to evaluate changes in selection patterns.

RÉSUMÉ

Ce document présente une analyse des données de fréquence des tailles (c-à-d. prise par taille, CAS) pour le thon obèse de l'Atlantique. Deux méthodes principales sont utilisées : des diagrammes de Powell-Wetherall visant à explorer les changements de Z sur la base des données de longueur et une analyse de la courbe de capture utilisant la prise par âge afin d'évaluer les changements de schémas de sélection.

RESUMEN

Este documento presenta un análisis de los datos de frecuencias de tallas (es decir, captura por talla, CAS) para el patudo del Atlántico. Se han utilizado dos métodos principales, diagramas de Powell-Wetherall para explorar los cambios en Z basándose en los datos de talla y un análisis de la curva de captura utilizando la captura por edad para evaluar cambios en los patrones de selección.

KEYWORDS

Bigeye, Catch-at-age, Catch-at-size, Catch curve analysis, Stock assessment

1. Introduction

This document presents an analysis of the length frequency data (i.e. catch-at-size, CAS) for Atlantic bigeye. Methods are used, indices based on length, Powell-Wetherall plots to explore changes in Z based on CAS and catch curve analysis using catch-at-age data (CAA) to evaluate changes in selection patterns.

2. Material and methods

Length-based methods are valuable methods for stock assessment, these can either be complex integrated stock assessment methods like Multifan-CL or simple methods with few assumptions. Cotter *et al*., 2004 in a review of stock assessment methods recommended the use of simple methods due to their visual appeal, simple statistical basis, minimal assumptions and the ease with which estimates can be derived from different data sets. A criticism of simple methods is that they do not estimate absolute stock numbers or fishing mortality but neither do other methods unless M is accurately known, as is seldom true.

Simple methods are also useful for validating data sets prior to their use in more complex methods as they can be used to identify anomalous results and are easier to understand.

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2.1 Material

The CAA data were those prepared for the 2015 bigeye assessment, the data used were those available on June 21, 2015. The intention is not to perform an assessment but to provide some diagnostics prior to the meeting, therefore not having the finalised data used in the assessment is not a problem.

2.2 Methods

Beverton and Holt, 1993 developed a method to estimate population parameters such as total mortality (Z) from length data e.g.

Based on this equation Powell, 1979 developed a method, extended by Wetherall *et al*., 1987, to estimate growth

$$Z = K\frac{L_\infty - \overline{L}}{\overline{L} - L'} \tag{1}$$

and mortality parameters. This assumes that the right hand tail of a length frequency distribution was determined by the asymptotic length L and the ratio between Z and the growth rate K. The Beverton and Holt methods assumes good estimates for K and L_∞, while the Powell-Wetherall method only requires an estimate of K, since L_∞ is estimated by the method as well as Z/K.These method therefore provide estimates for each distribution of Z/K, if K is unknown and Z if K is known.

As well as assuming that growth follows the von Bertalanffy growth function, it is also assumed that the population is in a steady state with constant exponential mortality, no changes in selection pattern of the fishery and constant recruitment. In the Powell-Wetherall method L' can take any value between the smallest and largest sizes. Equation 1 then provides a series of estimates of Z. Plotting equation 2 provides an estimate of L_∞ and Z/K. If K is known then it also provides an estimate of Z.

$$\overline{L} - L' = a + bL' \tag{2}$$

$$b = \frac{-K}{Z + K} \tag{3}$$

$$a = -bL_\infty \tag{4}$$

$$L_\infty = -a/b \tag{5}$$

$$Z/K = \frac{-1 - b}{b} \tag{6}$$

3. Catch curve analysis

Catch curve can be fitted to an actual or a "synthetic" cohort which uses catch data from a single year or a few years (Ssentongo and Larkin, 1973).

If p_a denotes the fraction of the total catch corresponding to age a then a linear regression of p_a can be fitted over a range of ages $[\alpha, \beta]$. As for the year-class curve analysis, the slope of the regression can be used to estimate the total mortality (Z), but we here applied for estimating selectivity. In theory, the ages that are not fully selected do not follow a linear to age a, then a linear regression on p_a over a.

Selectivities can be thus estimated from the ratio of observed to predicted catch proportions: then re-scaled so that the maximum is 1.

In other words, the selectivity is maximal (equal to 1) when there is no difference between the observed and expected curves and it becomes smaller as the difference between both curves increases.

4. Results

The CAS data available on June 22 2015 are plotted in **Figure 1**, and the mean lengths by baitboat, longline and purse seine in **Figure 2**. The three lines in **Figure 2** are length at infinity (L_{inf} , red), the length at which the population achieves its maximum biomass (L_{opt} , blue) and the length at which 50% of the population reach maturity (L_{50} green). These provide reference points against which the size distributions of the catches can be compared.

Powell-Whetherall plots are shown in **Figure 3** and the estimates of Z (points with hatched line) and a smoother (blue continuous line) in **Figure 4**.

The CAA derive from the CAS, using length slicing, are compared to the data used in the VPA in 2009 in **Figure 5,** the CAA themselves are presented in **Figure 6. Figure 7** shows the standardised residuals of the proportion of numbers-at-age per year. Due to variation in year-class strength it would be expected that strong and weak cohort s could be followed, i.e. a strong cohort recruiting to the fishing would be shown as a black row of dots moving diagonally from left to right.

Synthetic catch curves constructed by lustrum (5 years) are presented in **Figure 8** and the corresponding selection patterns in **Figure 9**. Catch curves by gear (baitboat, longline and purse seine) are presented in **Figure 10.**

Discussion

The Powell-Weatherall plots suggest that Z appears to be increasing, i.e. the number of larger fish in the population is declining. Although the average size of catches appears to be fairly consistent in the three main fisheries; longline catches appear to be equivalent to L_{opt}, while the bait boat and purse seine fleets are catching mainly immature fish. There was little evidence of cohort signals in the CAA data. The catch curve analysis base on age confirmed the analysis based on size alone, i.e. most catch is of juveniles although longlines are catching larger fish.

References

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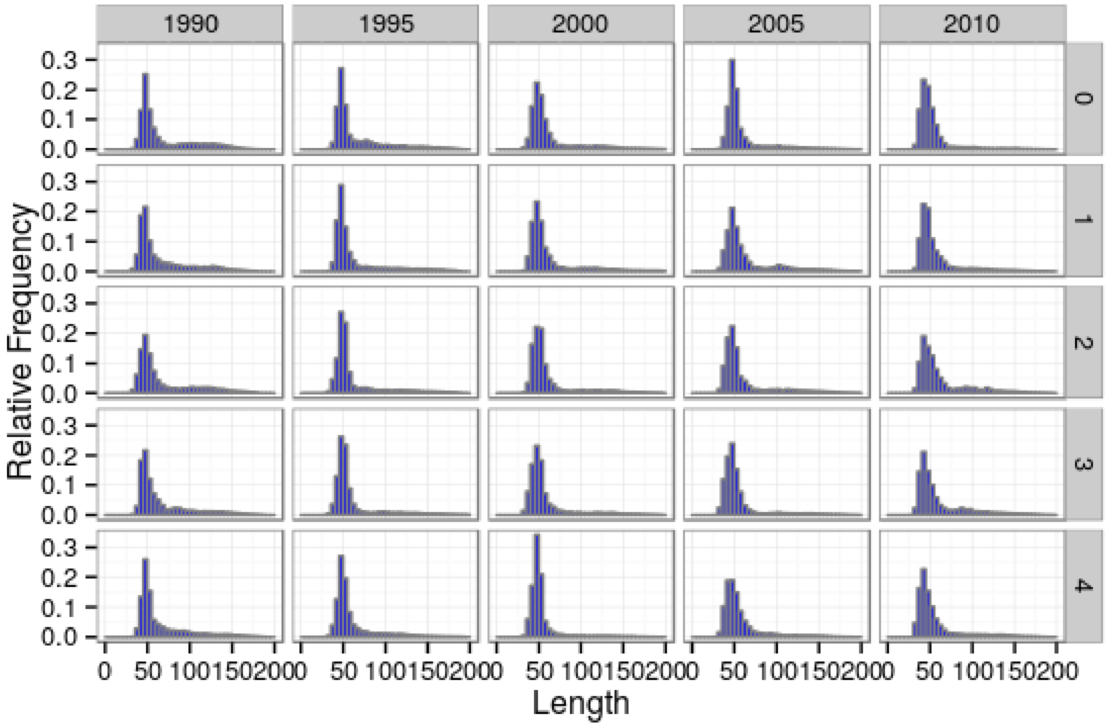

Figure 1. Catch length-at-age.

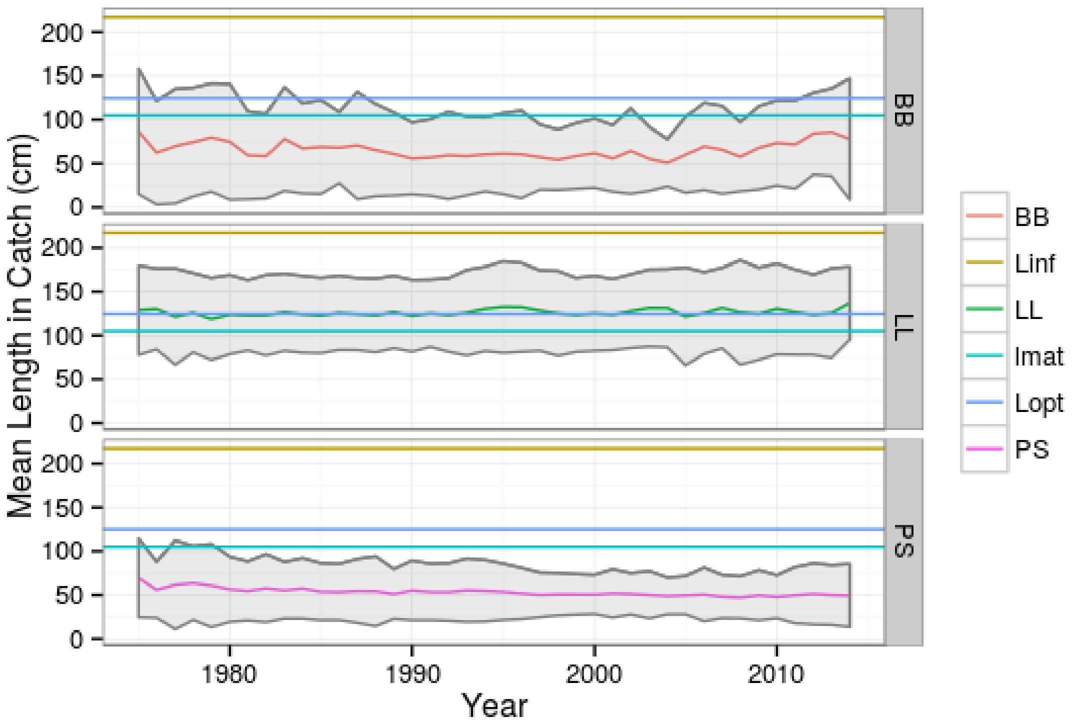

Figure 2. Catch length-at-age; horizontal lines are Linf (red), Lopt (blue) and L50 (green), ribbons are the mean length ± 2SDs.

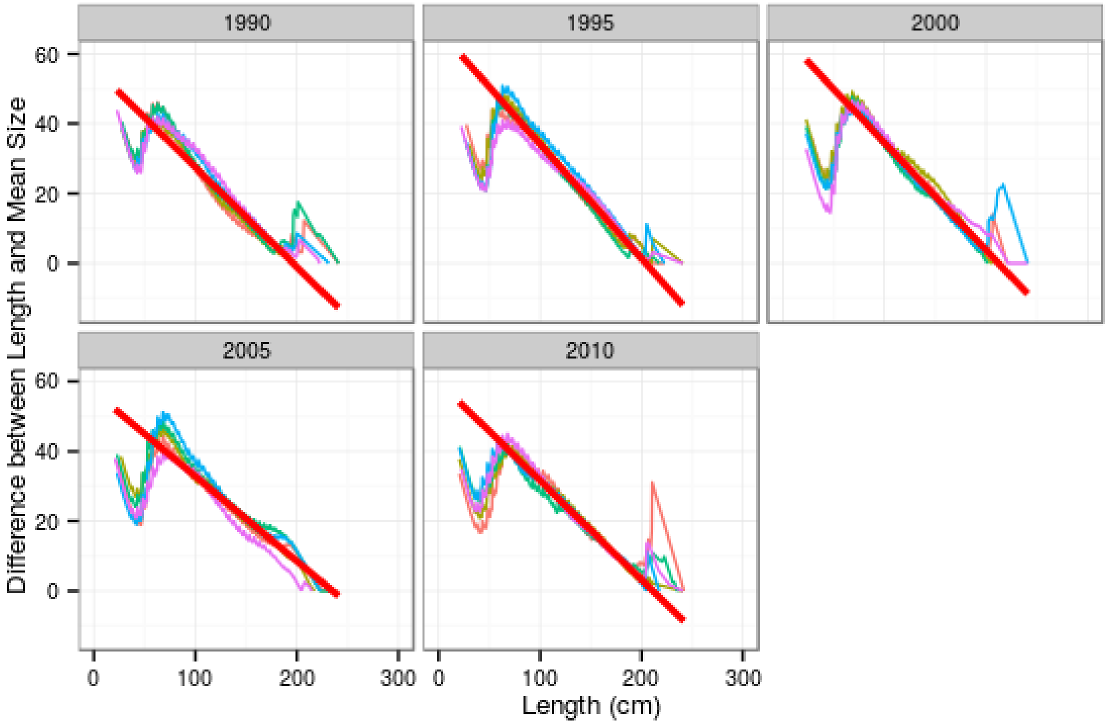

Figure 3. Powell-Whetherall plots.

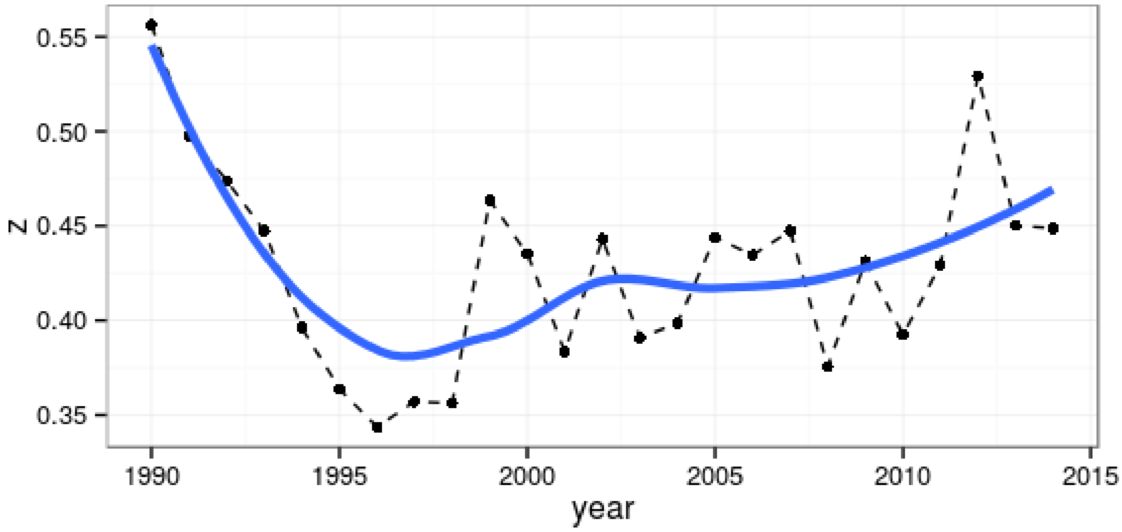

Figure 4. Estimates of Z derived from the Powell-Wetherall plots; showing the estimates from each year (points with hatched line) and a smoother (blue continuous line).

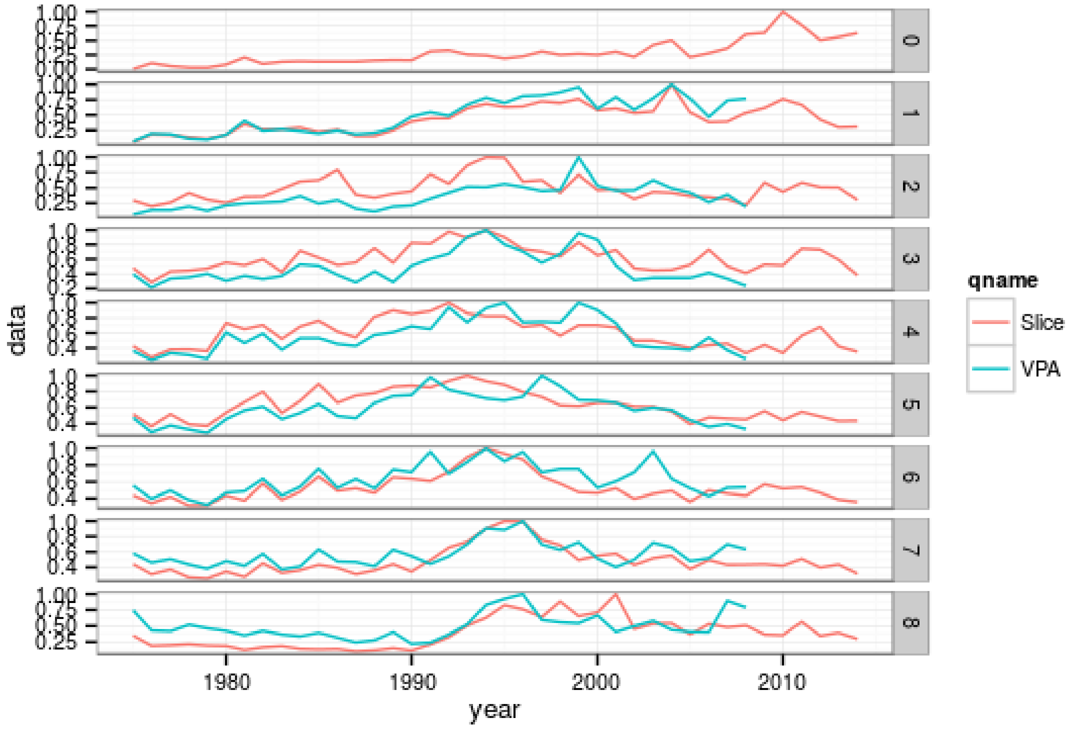

Figure 5. Comparison with CAA used in 2009 with sliced data.

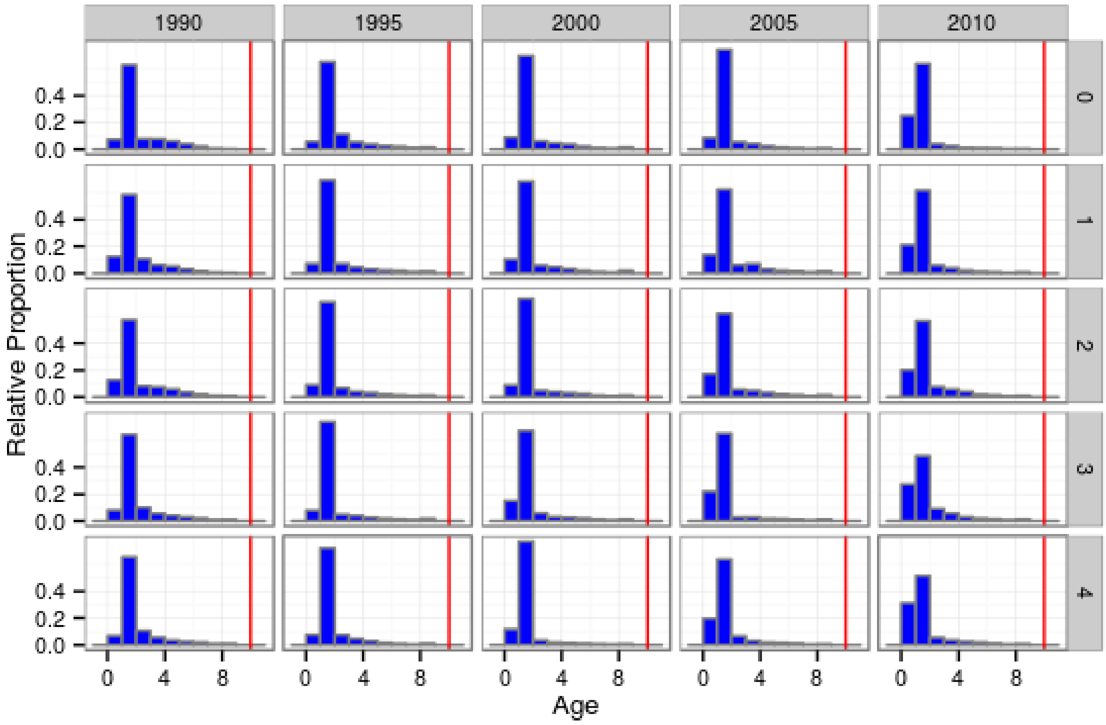

Figure 6. Catch numbers-at-age.

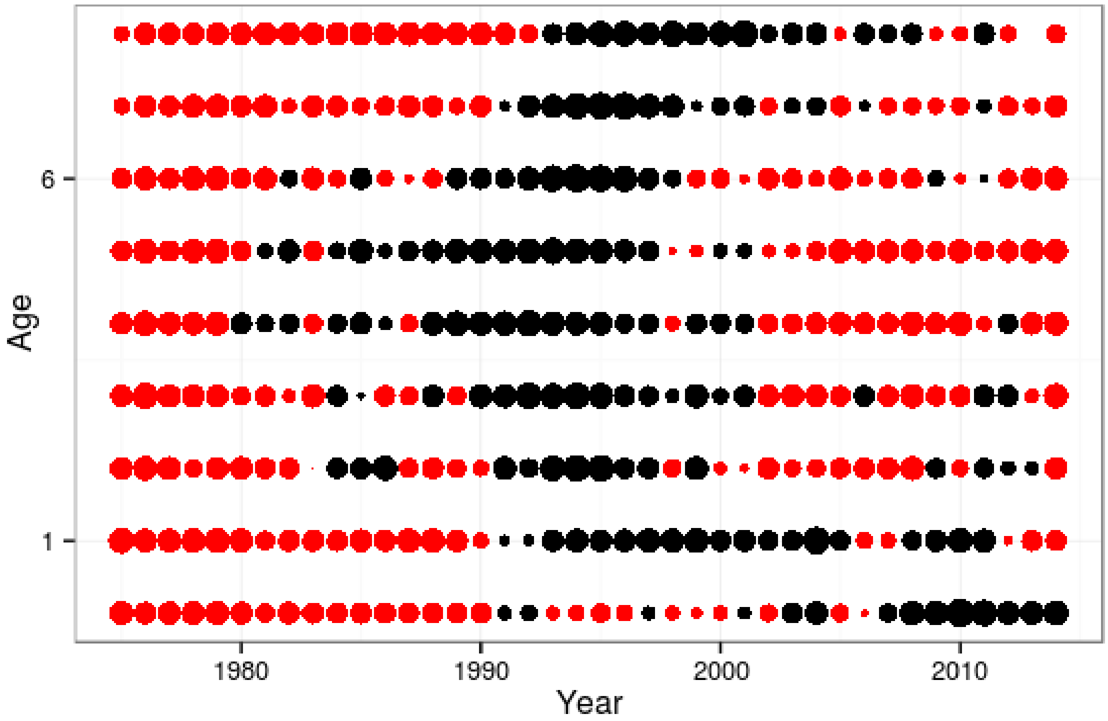

Figure 7. Standardised residuals of the proportion of numbers-at-age.

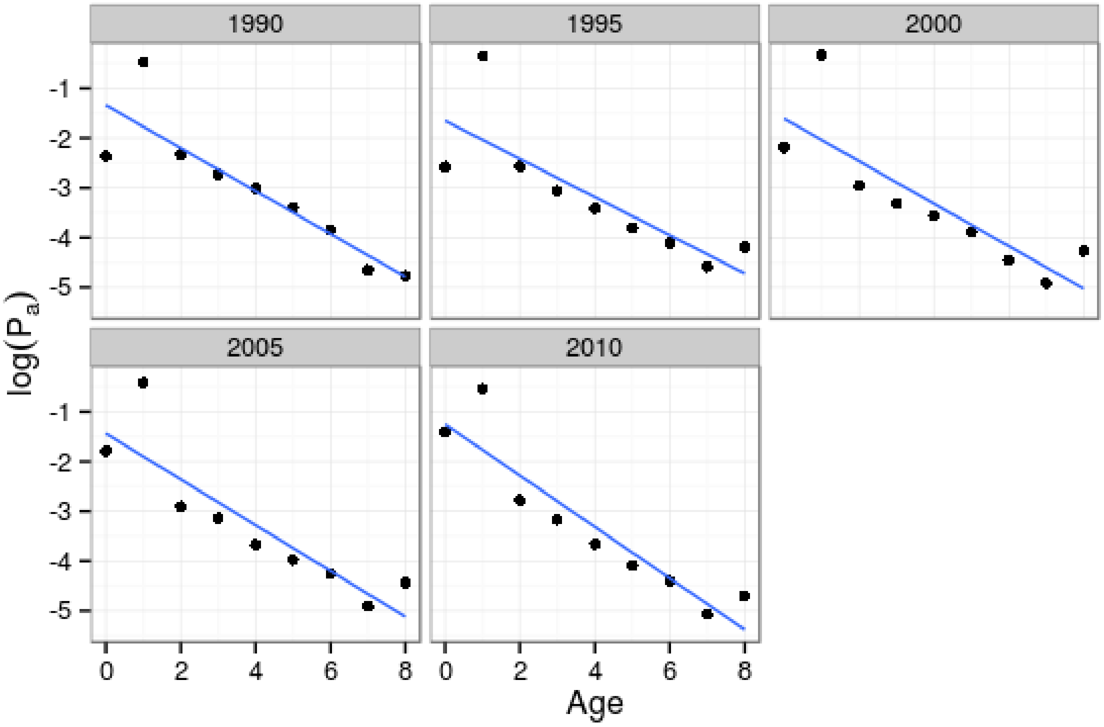

Figure 8. Catch curves by lustrum (Judge Parker: You've served this court for almost 2 lustrums. Rooster Cogburn: What's a lustrum, Judge? Judge Parker: Five years. Don't interrupt me.)

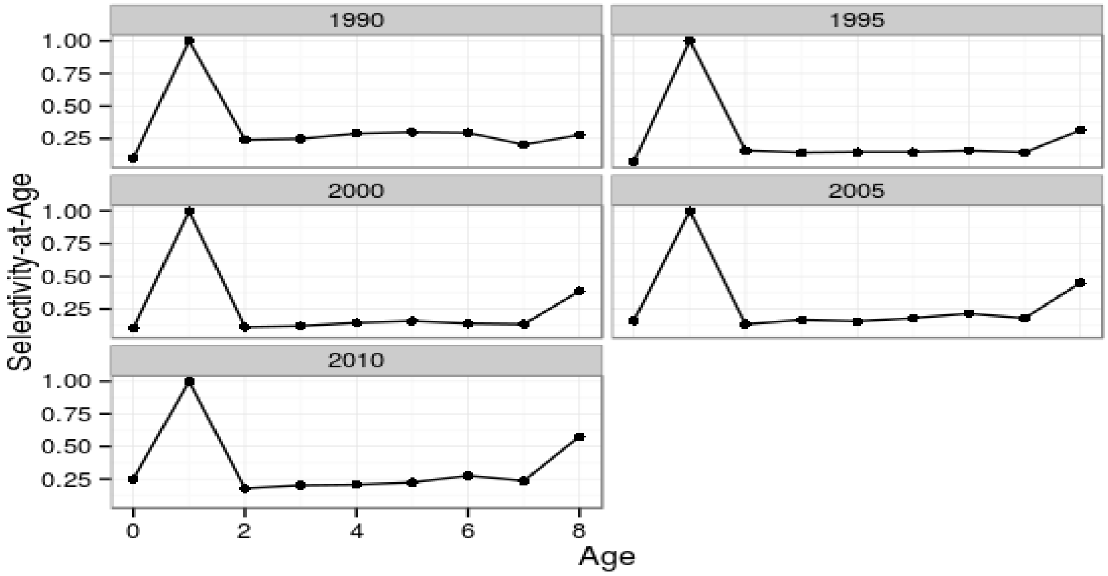

Figure 9. Selectivity by lustrum.

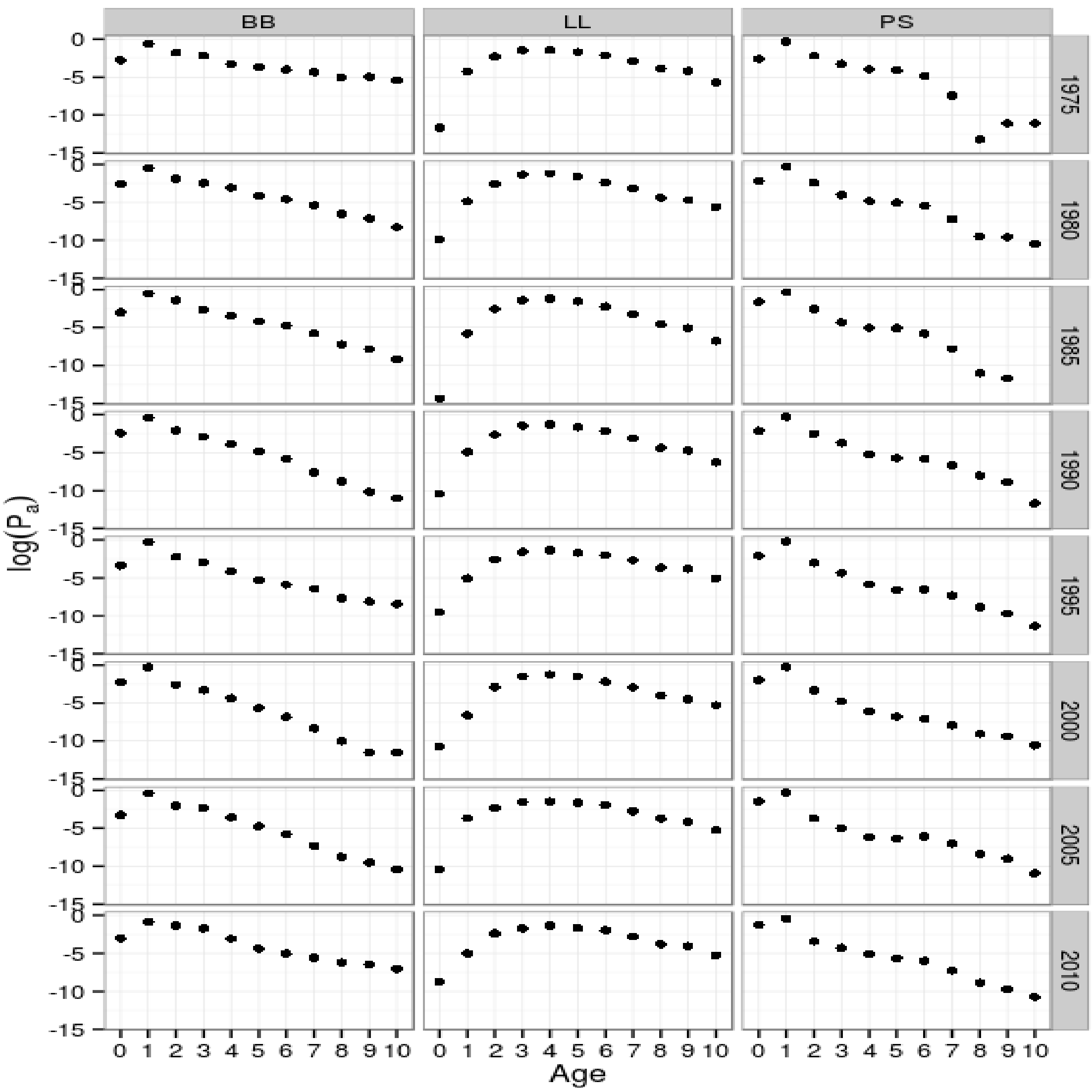

Figure 10. Catch curve by gear area interaction and lustrum.