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A LENGTH BASED ASSESSMENT FOR ATLANTIC BONITO (*SARDA SARDA*)

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SUMMARY

This document presents an analysis of length frequency data for Atlantic bonito using a simple length based assessment and life history parameters. Two methods are used, i.e. Powell-Wetherall plots to explore changes in Z based on length samples and catch curve analysis using lengths converted to age using cohort slicing to evaluate changes in selection patterns. The potential for conducting assessments of information limited stocks and for use as part of an Ecological Risk Assessment to identify a hierarchy of species and stocks is discussed.

RÉSUMÉ

Le présent document fait état d'une analyse des données de fréquence de tailles de la bonite à dos rayé réalisée au moyen de l'évaluation simple fondée sur la longueur et des paramètres du cycle vital. Deux méthodes sont utilisées, à savoir des diagrammes de Powell-Wetherall visant à explorer les changements de Z sur la base d'échantillons de tailles et d'une analyse de la courbe de capture utilisant des longueurs converties en âge au moyen d'un découpage des âges afin d'évaluer les changements de schémas de sélection. On se penche sur le potentiel de la méthode qui pourrait être utilisée dans les évaluations des stocks pour lesquels peu de données sont disponibles et servir partiellement à l'évaluation des risques écologiques afin d'identifier une hiérarchie des espèces et stocks.

RESUMEN

Este documento presenta un análisis de los datos de frecuencia de tallas para el bonito del Atlántico empleando una simple evaluación basada en la talla y parámetros del ciclo vital. Se utilizan dos métodos, a saber, diagramas Powell-Wetherall para explorar los cambios experimentados por Z basándose en las muestras de talla, y un análisis de la curva de capturas utilizando tallas convertidas a edad mediante separación de cohortes para evaluar los cambios en los patrones de selección. Se debate el potencial de este método para realizar evaluaciones de stocks con información limitada y para utilizarse como parte de una Evaluación de Riesgo Ecológico a la hora de identificar una jerarquía de especies y stocks.

KEYWORDS

Bonito, Data limited, Data poor, Catch-at-size, Catch curve analysis,
Ecological risk assessment, Length frequency, Life histoty traits, Small tuna, Stock assessment

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Introduction

This document presents an analysis of length frequency samples for Atlantic bonito (*Sarda sarda*). Two methods were used, Powell-Wetherall plots to estimate Z and catch curve analysis and age slicing to evaluate vulnerability-at-age (i.e. selection pattern).

Material and Methods

Length-based methods can either be complex integrated stock assessment methods 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 the more complex methods unless M is accurately known.

Simple methods are also useful for validating data sets prior to their use by complex methods as they can be used to identify anomalous results and are easier to explain and understand in a working group context. The methods used here have been used previously in the Atlantic bluefin assessment (SCRS/2015/115), i.e. a "data rich" assessment based on virtual population analysis (VPA). The simple approach gave similar results to the "data rich" analysis; i.e. the data rich assessment validated the data poor approach.

Material

The length frequency data for the Atlantic Bonito during the period 2012-2014 came from the biological sampling conducted on a monthly basis in the ports of Dakhla and Laayoune located south of Morocco where most of small tunas landing were recorded. The fork length of fish (FL) was taken to the nearest centimetre using a graduated woody broad. The catch at size were estimated by raising the size frequency data to the total catch of vessel then to the total catches by ports.

Life parameters were obtained from Lucena *et al.* (this volume) and https://github.com/fishnets/fishnets.

Methods

$$Z = K\frac{L_{\infty} - \overline{L}}{\overline{L} - L'} \quad (1)$$

Beverton and Holt (1956) developed a method to estimate total mortality (Z) from length data i.e.

Based on this equation Powell (1979) developed a method, extended by Wetherall *et al.* (1987), to estimate growth and mortality parameters. This assumes that the right hand tail of a length frequency distribution is determined by the asymptotic length (L), 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. The method therefore provide estimates for Z/K, if K is unknown and Z if K is known. Estimates of L_∞ can be used as a form of validation, i.e. do the estimates agree with values from the literature.

It is assumed that growth follows the von Bertalanffy growth function, growth rates remain constant across cohorts and that a single growth curve can be used to describe both sexes which have equal catchability. It is also assumed that the population is in a steady state with constant exponential mortality, rates of natural mortality are constant across older ages, there have been no changes in selection pattern of the fishery which is asymptotic selectivity and that recruitment has been constant.

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.

$$\overline{L} - L' = a + bL' \qquad (2)$$

$$b = \frac{-K}{Z + K} \qquad (3)$$

$$a = -bL_{\infty} \qquad (4)$$

$$L_{\infty} = -a/b \qquad (5)$$

$$Z/K = \frac{-1 - b}{b} \qquad (6)$$

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 P. 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 is also the case for the year-class curve analysis, the slope of the regression can be used to estimate the total mortality (Z), but here we use the method to estimate selectivity, due to the known bias in estimates of F obtained from age slicing (Kell and Kell) 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.

Results

The length frequency samples are shown in **Figure 1,** scaled by month and year (i.e. plotted as relative proportions with a panel). The same data are plotted by year in **Figure 2,** showing the relative sampling level by month. Life history parameters are summarised in **Figure 3**.

The Powell Weatherall plots (**Figure 4)** show both the observations (points with hatched line) and fits by year. The estimates of z/k and L_∞ are presented **Figure 5,** the horizontal line is for comparison assuming natural mortality=0.2, and summarised in **Table 1**. As a check, estimates of L_∞ are summarised in **Figure 6;** these are similar to those found in the life history database which gives confidence in the fits.

Catch-at-age generated from the length samples by age slicing (**Figure 7)** were then used to generate synthetic catch curves (**Figure 8**) and the selection patterns are presented in **Figure 9**.

Discussion and Conclusions

The anlaysis was able to provide estimates of total mortality and selection pattern. If natural mortality is assumed to be 0.2 (John Pope, pers comm.) then fishing mortality is on average about twice this level, implying that the stock is fully exploited. The selection pattern suggests that older fish are less vulnerable to fishing. However age slicing will under-estimate the selection pattern at older ages, as the method will misassign catches from strong year classes to older ages.

The approach has been validated using a data rich stock, i.e. Atlantic bluefin, and can be applied to all stocks, e.g. small tuna and by caught teloests to help conducting assessments of information limited stocks and for use as part of an Ecological Risk Assessment (ERA), to identify a hierarchy of species and stocks.

As pointed out by Lucena *et al.* (this volume) ERA, also known as productivity and susceptibility analysis, is a methodology to the vulnerability of a stock becoming overfished based on its biological productivity and susceptibility to the fisheries. The approach can help decision makers focus management actions and assessment and data collection priorities.

References

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Table 1. Estimates of z/K and $L[\infty]$

Year	z/k	$L_{infinity}$
2012	3.76	68.5
2013	2.72	71.6
2014	2.67	68.1

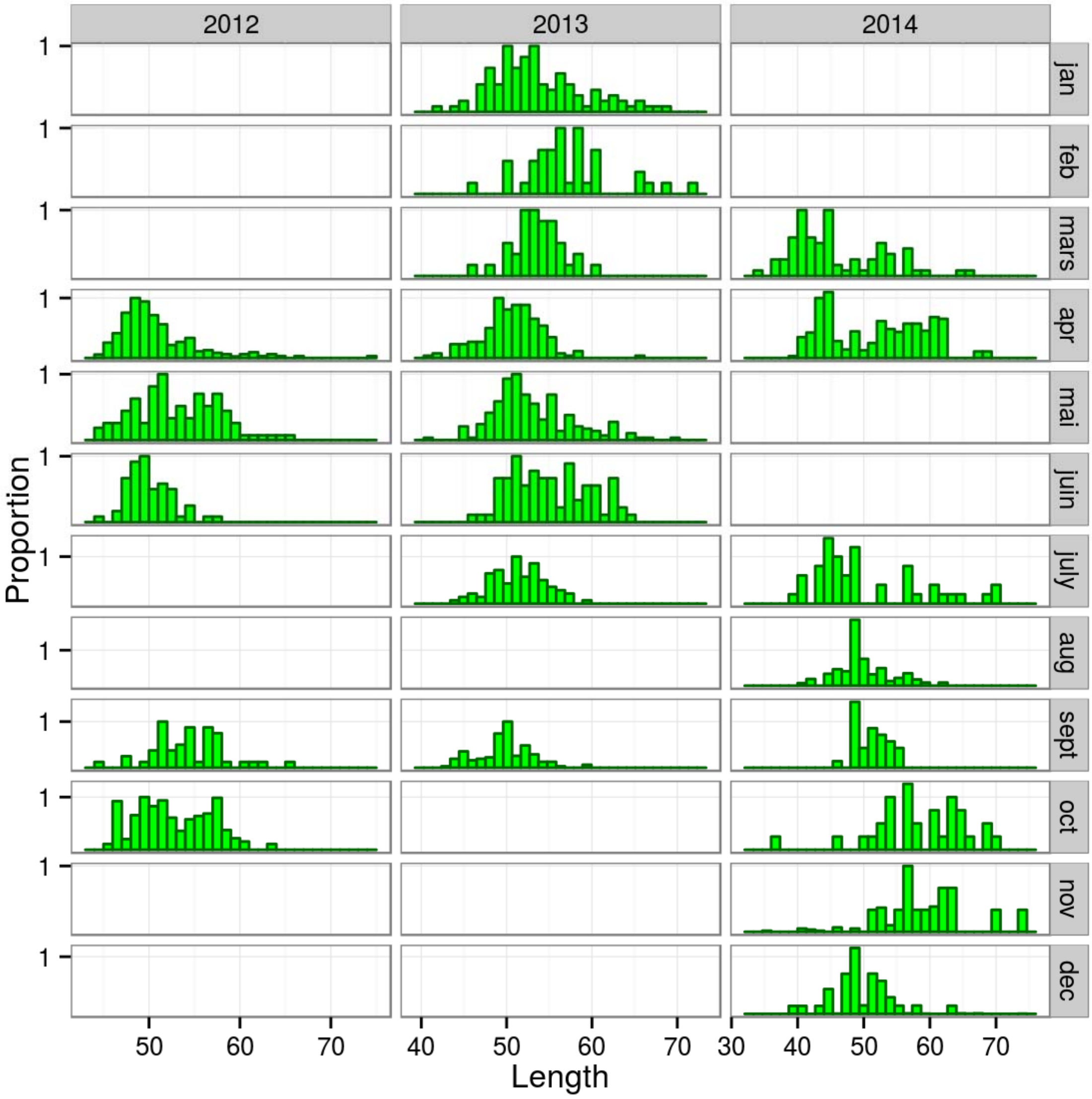

Figure 1. Length frequencies by month and year.

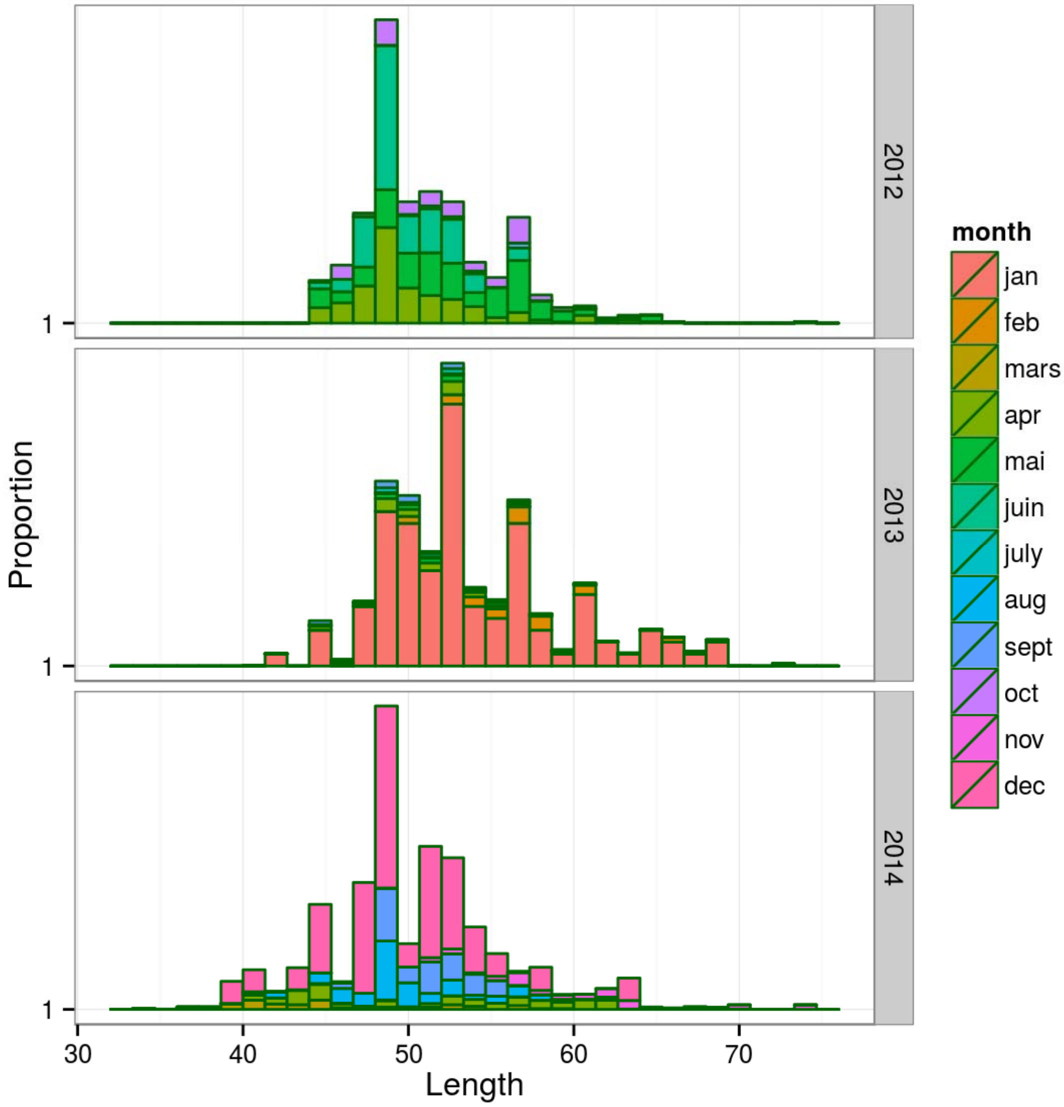

Figure 2. Length frequencies by year.

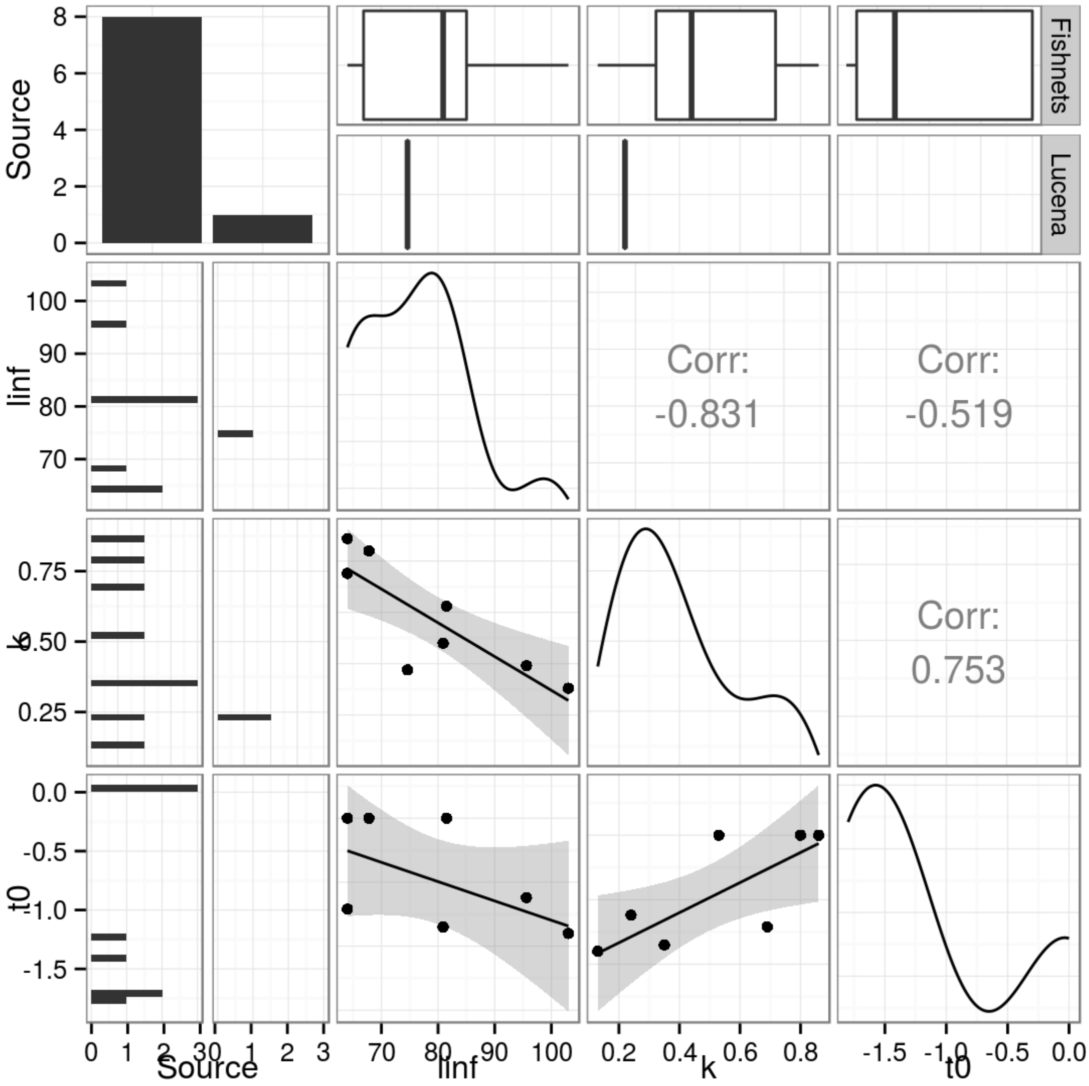

Figure 3. Life history parameters.

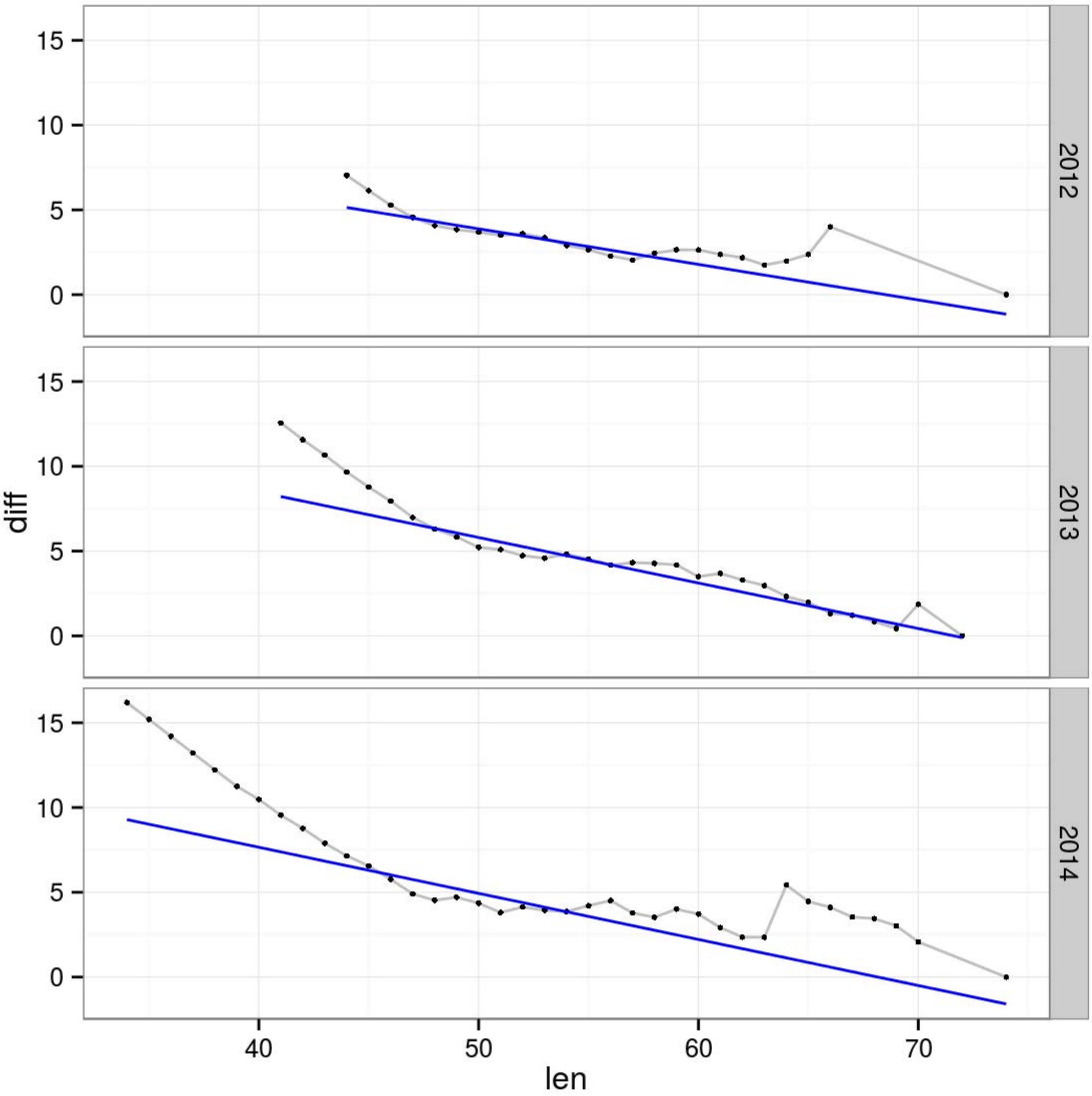

Figure 4. Powell-Wetherall plots.

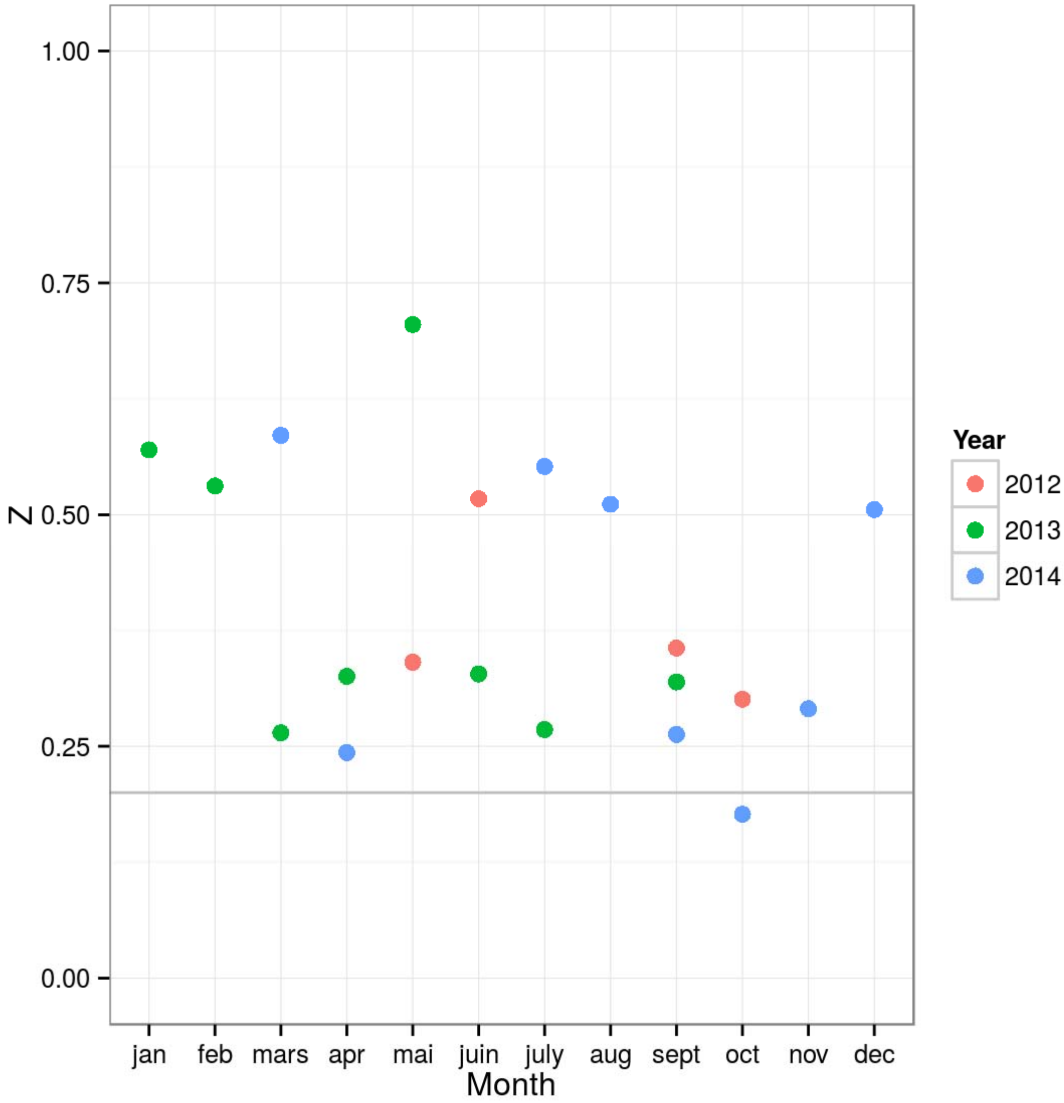

Figure 5. Estimates of F by month, horizontal line is an assumed value of M of 0.2.

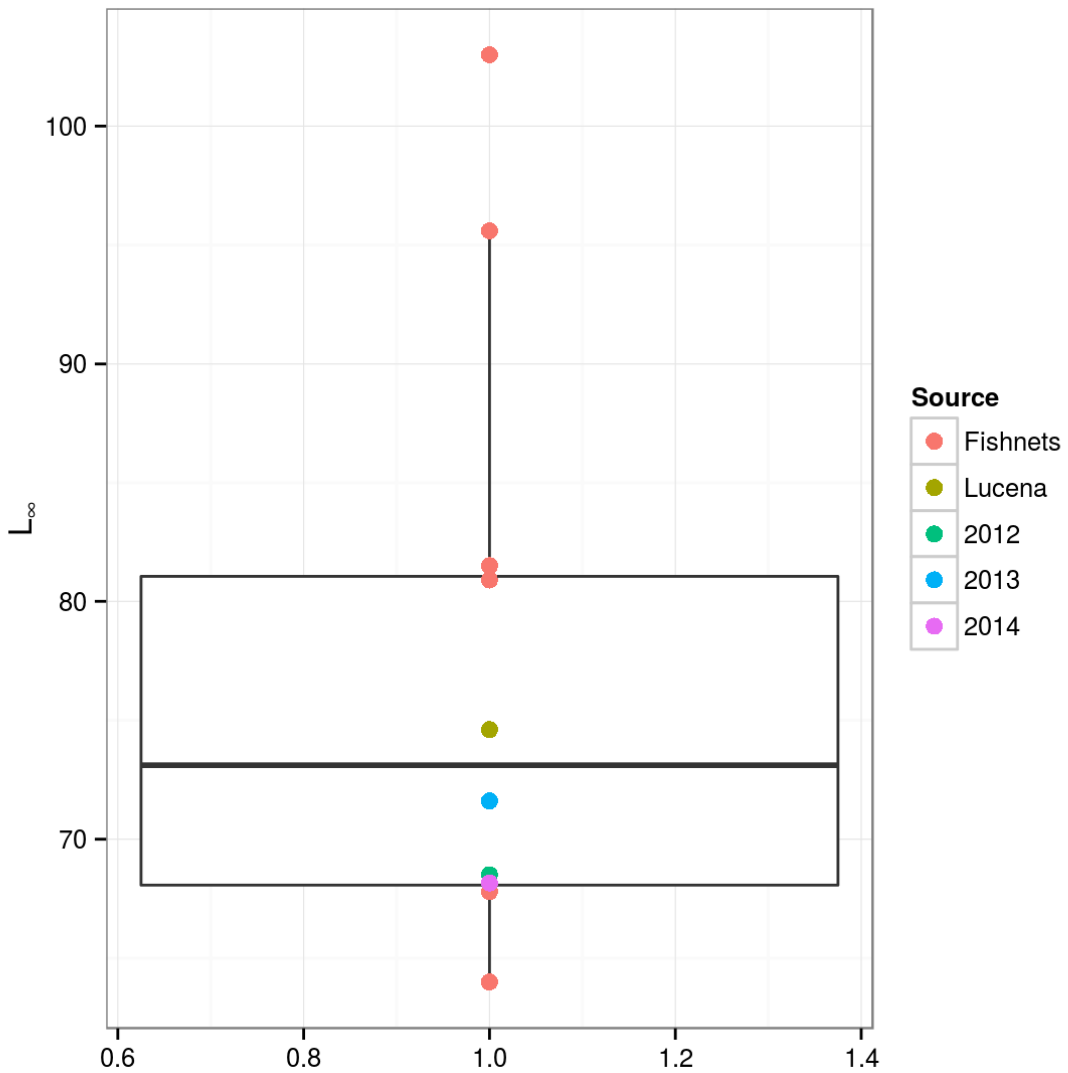

Figure 6. Comparison of values of $L_{}$ estimates with Fishnets and Lucena *et al.*

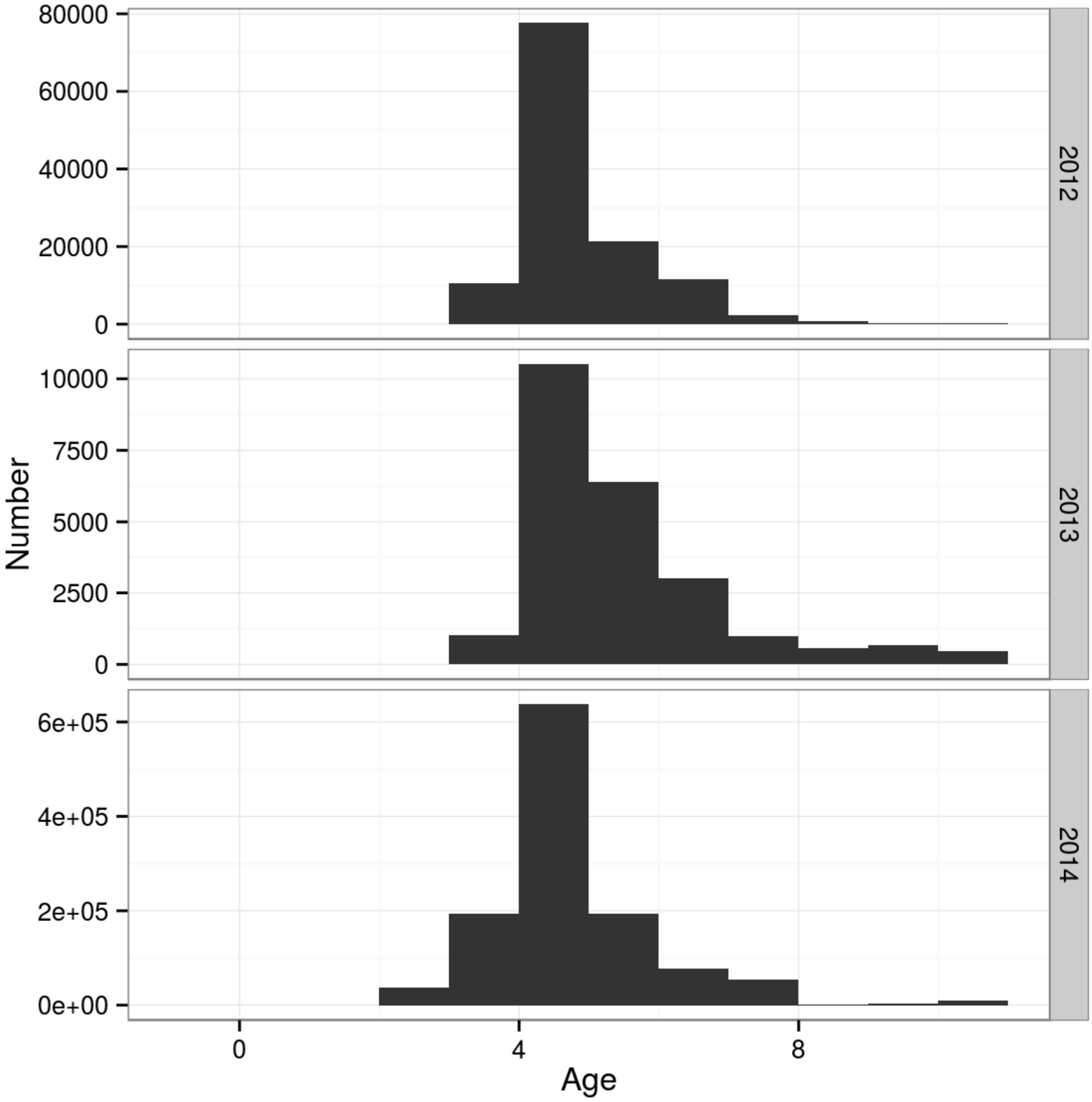

Figure 7. Catch-at-age.

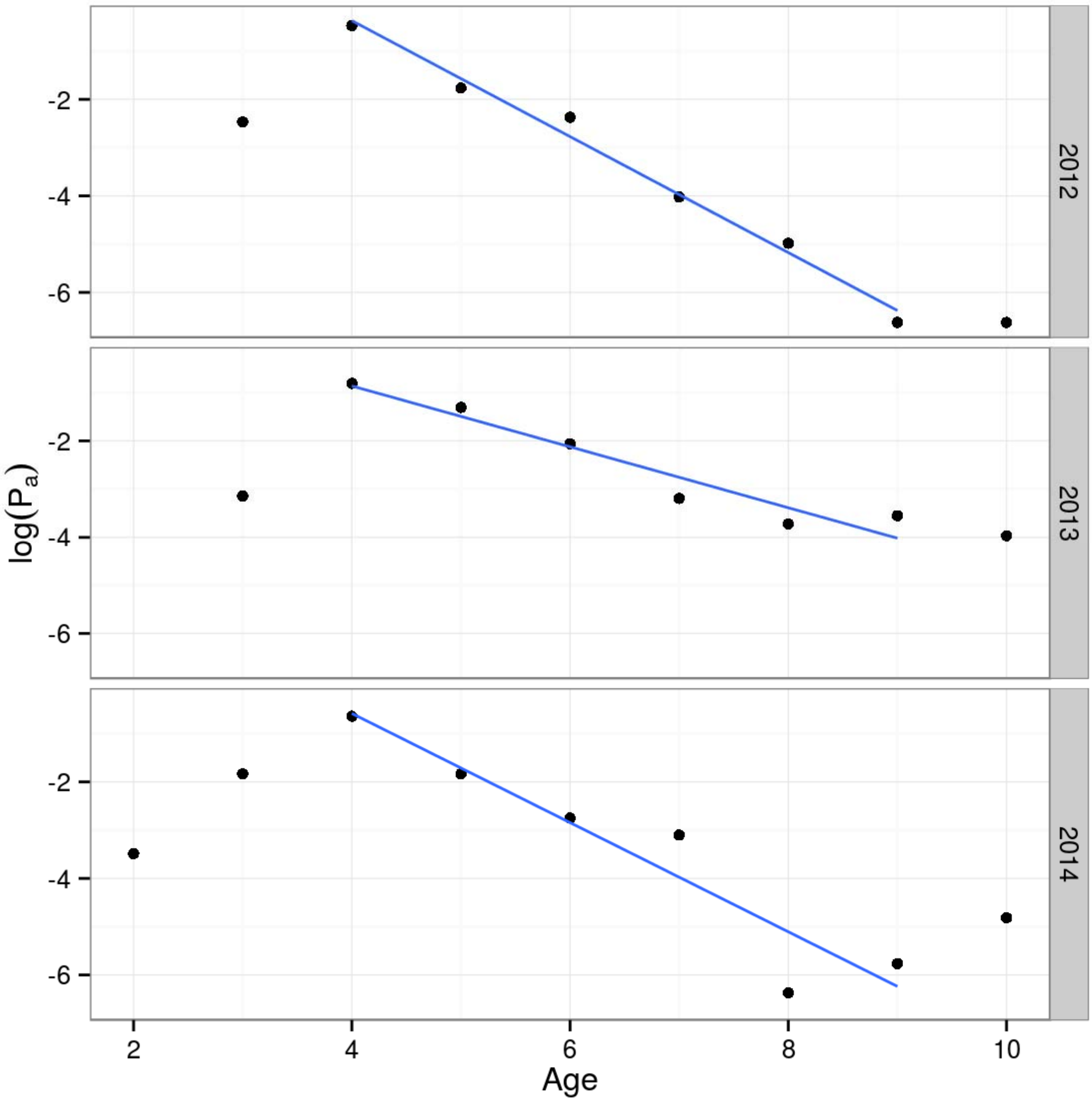

Figure 8. Catch curve analysis.

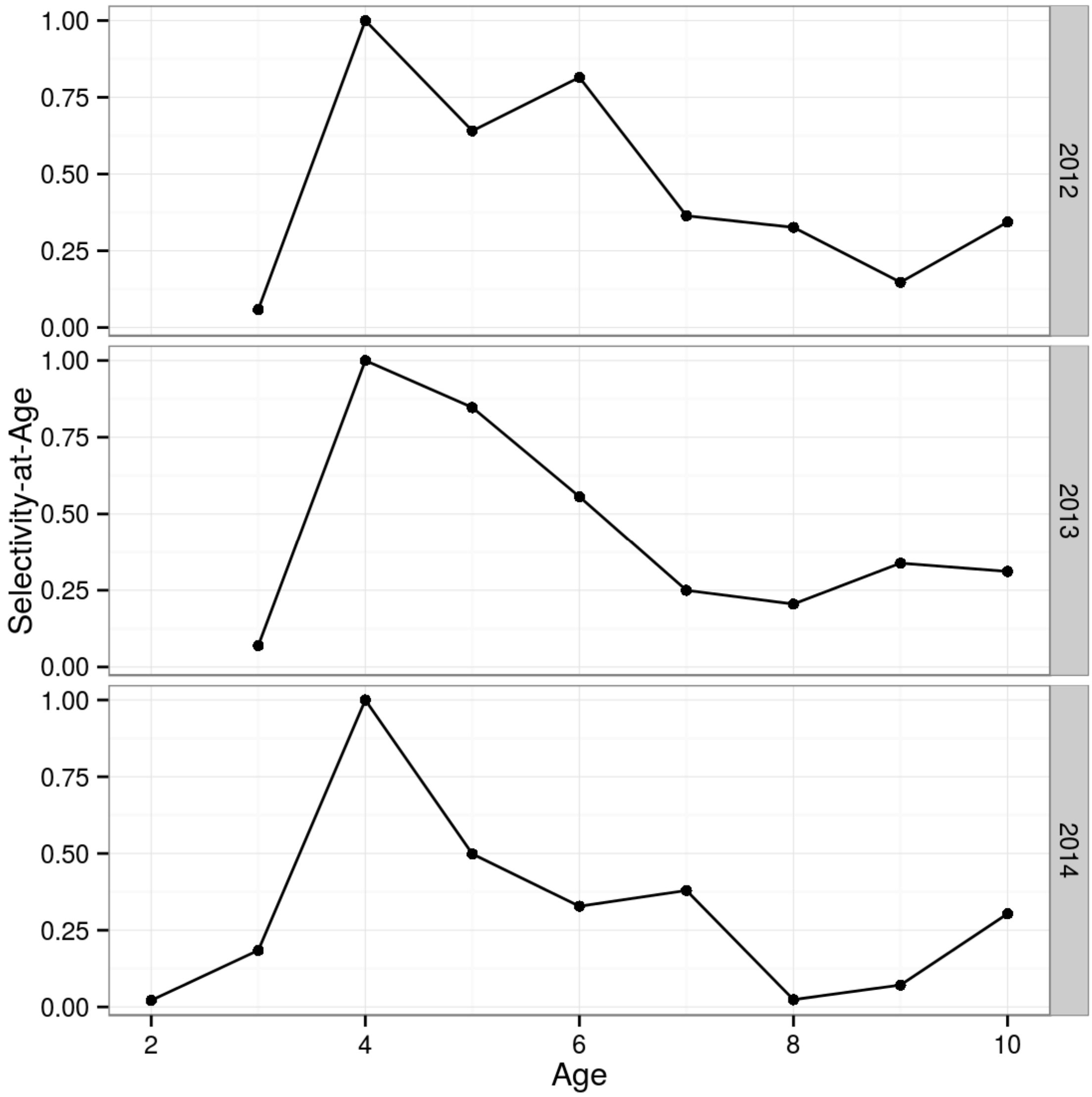

Figure 9. Selection patterns.