CATCH-AT-SIZE AND AGE ANALYSIS FOR ATLANTIC SWORDFISH

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SUMMARY

Analyses of the Task II Atlantic swordfish data provide insights into the change in selectivities, Z, size and age composition of both the northern and southern Atlantic swordfish stocks.

RÉSUMÉ

Les analyses des données de tâche II de l'espadon de l'Atlantique donnent un aperçu de la variation des sélectivités, de Z, de la taille et de la composition par âge des stocks d'espadon de l'Atlantique Nord et Sud.

RESUMEN

Análisis realizados a los datos de Tarea II del pez espada del Atlántico proporcionan información sobre los cambios en las selectividades, Z, y la composición por tallas y edades de los stocks de pez espada del Atlántico norte y sur.

KEYWORDS

Atlantic Swordfish, Size data, Selectivity, Z, Catch composition

1. Introduction

The Task II size data (**Figure 1**) is used to determine how the north and south Atlantic Swordfish fisheries have changed over the period from 1970 to 2015. Trends will support the interpretation of the assessment models reviewed at the 2017 Atlantic Swordfish assessment meeting held July 2 to 6 in Madrid. This follows in principle the work of Kell et al. 2016 which was provided in support of the 2015 Atlantic Bigeye tuna assessment.

2. Method

The analyses are based on Task II size data submitted to ICCAT for the period 1970 to 2015. Values for L_∞, K, t_o, a_{50} and L_{50} (336, 0.157, -2.1, 4, 156) were based on studies of unsexed Swordfish. L_{50} is the lower bound for females and M was derived from the formula:

$$log_{10}(M) = 0.566 - 0.718 \times (log_{10}L_\infty) + 0.02 * T$$

where T is the mean annual preferred temperature in degrees Celsius (20) and M was estimated to be 0.142 (Froese et al. in prep).

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The length at optimum yield, L_{opt}, was calculated using estimates of K, L_∞ and M (Beverton 1992) as:

$$L_{opt} = L_\infty \left(\frac{3}{\left(3 + \frac{M}{K}\right)} \right)$$

(Froese and Binohlan 2000).

Total mortality was estimated using both the Powell-Wetherall method and by estimating the slope of a catch curve derived from age sliced catch at length data (Sparre and Venema 1998). Pseudo cohorts, representing the average numbers caught per age group within lustrums, were fit with a linear regression over ages 3 to 9 yielding estimates of both Z and selectivity at age.

3. Results

The composition of the catch in both the northern and southern Atlantic looks similar before and after the implementation of size regulations (**Figure 2**).

The mean length of the catches by gill nets and long lines has been trending upwards and is slightly above L_{mat}, though to a greater degree in the Southern Atlantic (**Figure 3**). The mean length of fish caught by the harpoon fleet in the north Atlantic is closer to L_{opt} than any fleet in the entire Atlantic Ocean.

Estimates of Z and L_∞ were calculated using the Powell-Wetherall method. The trend in Z in the northern Atlantic shows a reduction from the series high in 1996 of 0.7 to a low of 0.2 in 2015 (**Figure 4 and Figure 5)**. For the southern stock, Z declines from a high in 2003 of 0.6 to a low of 0.4 in 2015. L_∞ increased to a high of 285 cm in 1997 in the northern stock and declines to a series low of 240 cm in 2015, whereas the southern stock shows an increase to 275 cm by 2003 and very little change since.

The age composition time series shows the southern fisheries catching proportionately less fish than their historic maxima at each age compared with the north (**Figure 6**).

The proportions at age show some variability by year and lustrum both within and between stocks; however, trends are difficult to detect though recently more fish appear to be above the reference age of 4 (**Figure 7**). Age 4 is viewed by some as the age at which 50% of the population is mature and according to the plots, most of the catch has been younger than that.

An increasing number of older fish are being caught in the north and south relative to historic values. In the south there is a tendency to catch or report the catch of age 0 fish compared to the north (**Figure 8**)**.** The plot also shows that age assignment using cohort slicing, which assigns fish of a given length to a broader range of ages and uses a seasonal adjustment, has the same patterns but with the increase in older fish in the catch including age 6 and 7.

Assuming a constant parameter system (i.e. recruitment, F and M remain constant so that Z estimated from a pseudo cohort is approximately equal to Z estimated for a true cohort), catch curves based on the average number caught per age group within a lustrum yielded estimates of Z and selectivity. Estimates of Z were restricted to fully selected ages 3 to 9. Ages were estimated from the catch at length data using cohort slicing. The trend in Z for both stocks is similar with initially low Z during the period of the mercury ban followed by 15 to 20 years of relatively high Z (**Figure 9**, **Figure 10, Figure 12**Figure 12 and **Figure 15)**. Over this period, Z was on average higher for the northern stock. Following this period, Z declined to 0.25 in the south but remained high in the north at 0.52. The terminal estimate is based on a single year and the relative difference is smaller for the penultimate lustrum with values of 0.67 and 0.58 respectively. In the north, the average estimate of Z for harpoon was 0.05 compared to about 0.25 for handline and longline gears while longline gears in the south had a lower average Z of about 0.20. Estimates of Z were similar for longline gear under cohort slicing and the inverse von Bertalanffy growth equation.

Selectivities at age are fairly similar across lustrums for the southern stock whose catch at length data is primarily provided by OT (gill net?) and long line gear. In the north, where selectivities are based on several gear types including HL, HP, and LL, selectivities on older fish are increasing in the more recent 5 to 10 years evident (**Figure 11).** In the south, the cohort slicing approach results in a consistent selectivity pattern for the gears over time (**Figure 14**). LL selectivities are relatively similar across lustrums with the exception of the first 10 years when older fish are caught. In the north, the selectivities of the HP gear type are consistent across lustrums and show an emphasis on older fish compared to the other gear types. LL selectivities were high on older fish and young fish in the first 10 years but more recently are focused on younger fish. Interpretation of the selectivity estimated from the inverse von Bertalanffy method is more difficult (**Figure 13**).

4. Conclusions

1. The mean length of the catch above the length of maturity appears to be increasing in the north as well as the south.

2. The proportion of the catch below 120 cm appears to be unaffected by minimum size regulations established in 1990.

3. Total mortality is estimated to be declining for both stocks, regardless of method. In the north this may be a function of lower F on young fish while in the south the decline in F affects all age classes. Thought the trends are similar, the Powell-Whetherall method estimates Z to be lower in the north than in the south while the catch curve method indicates the reverse is true.

4. Selectivity is not constant in either the north or south and is highest on younger fish among longliners fishing in the north Atlantic.

References

Beverton, R. J. H. (1992). Patterns of reproductive strategy parameters in some marine teleost fishes. J. Fish Biol. 41(Suppl. B), 137-160.

Froese, R., and C. Binohlan. 2000. Empirical relationships to estimate asymptotic length, length at first maturity and length at maximum yield per recruit in fishes, with a simple method to evaluate length frequency data. Journal of Fish Biology 56:758-773.

Kell, L., Palma, C. and Merino, G. 2016. Catch-at-Size and Age Analyses for Atlantic Bigeye. Collect. Vol. Sci. Pap. ICCAT, 72(2): 497-504 (2016)

Sparre, P., Venema, S.C., 1998. Introduction to tropical fish stock assessment. Part 1. Manual. FAO Fisheries Technical Paper, (306.1, Rev. 2). 407 p.

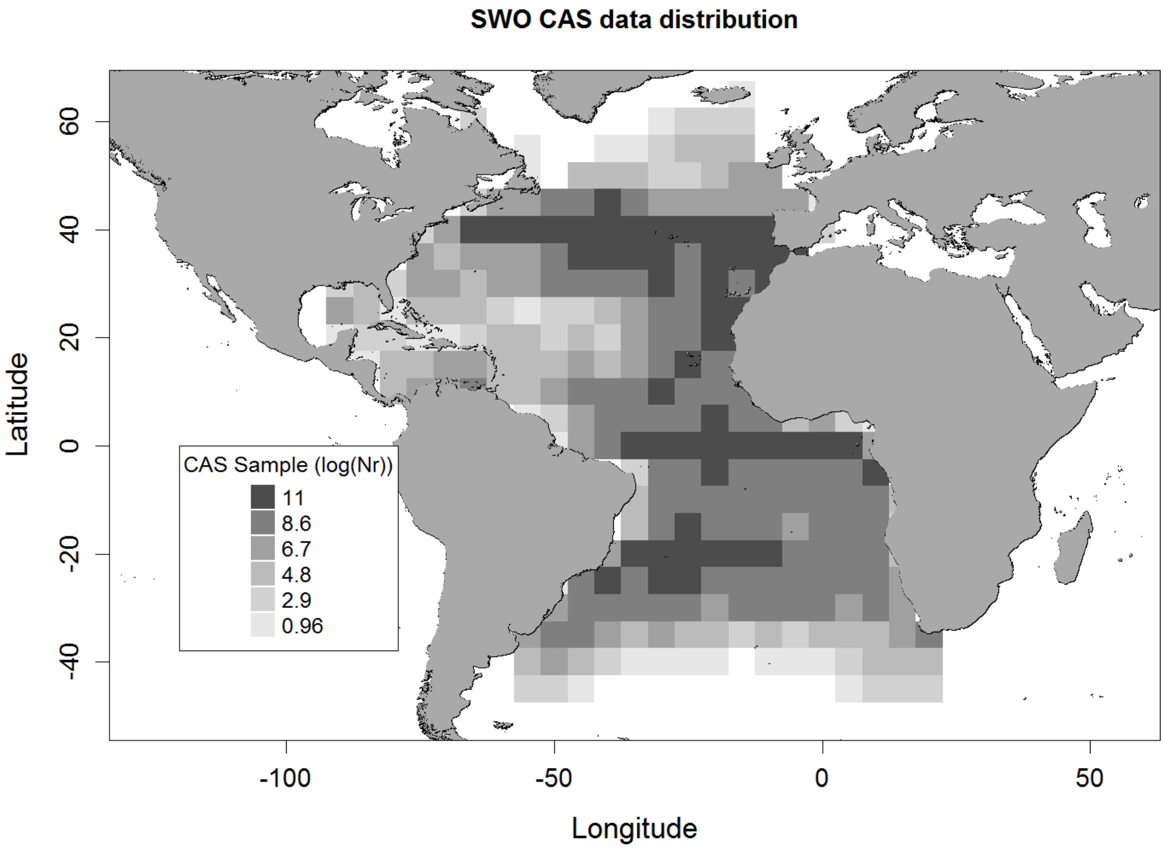

Figure 1. Task II Swordfish catch at size observations from 1970 to 2015 aggregated by 5x5 square.

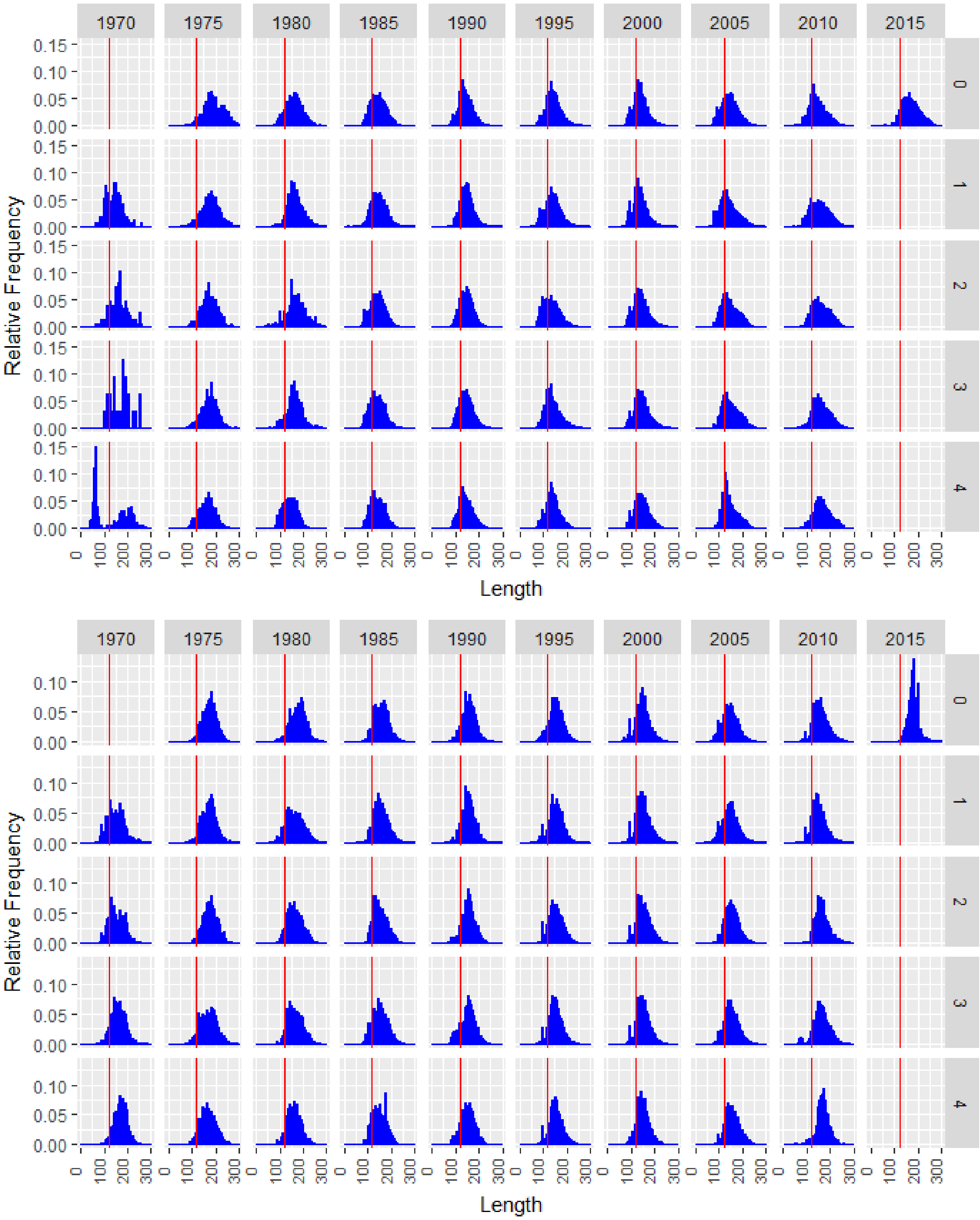

Figure 2. Length distribution of the northern (top) and southern (bottom) Atlantic Swordfish catch. The vertical red line is at 120 cm.

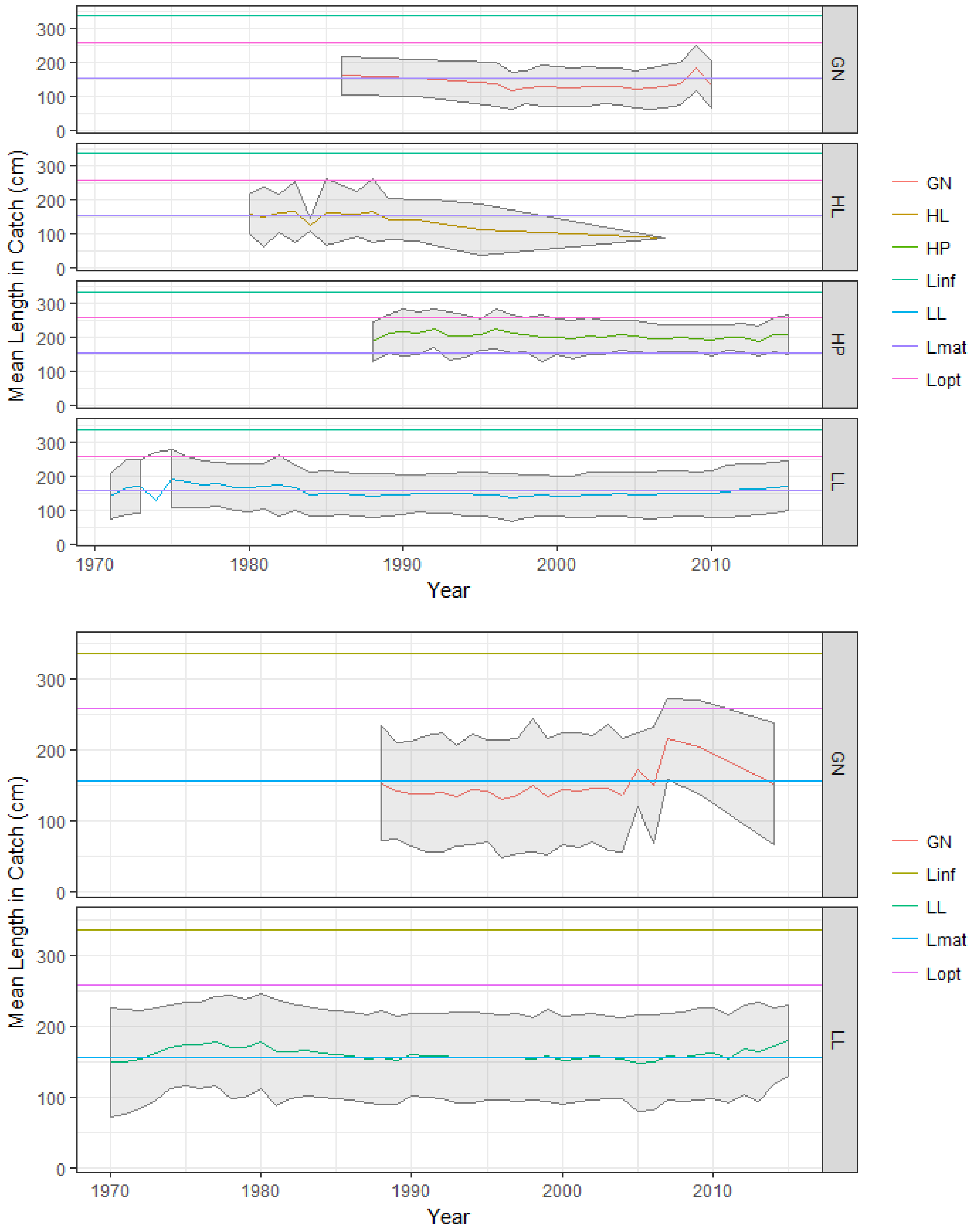

Figure 3. Mean length of Atlantic Swordfish catch by dominant gears and stock (north is top; south is bottom); horizontal lines are Linf (olive), Lopt (pink) and L50 (blue), ribbons are the mean length ± 2SDs.

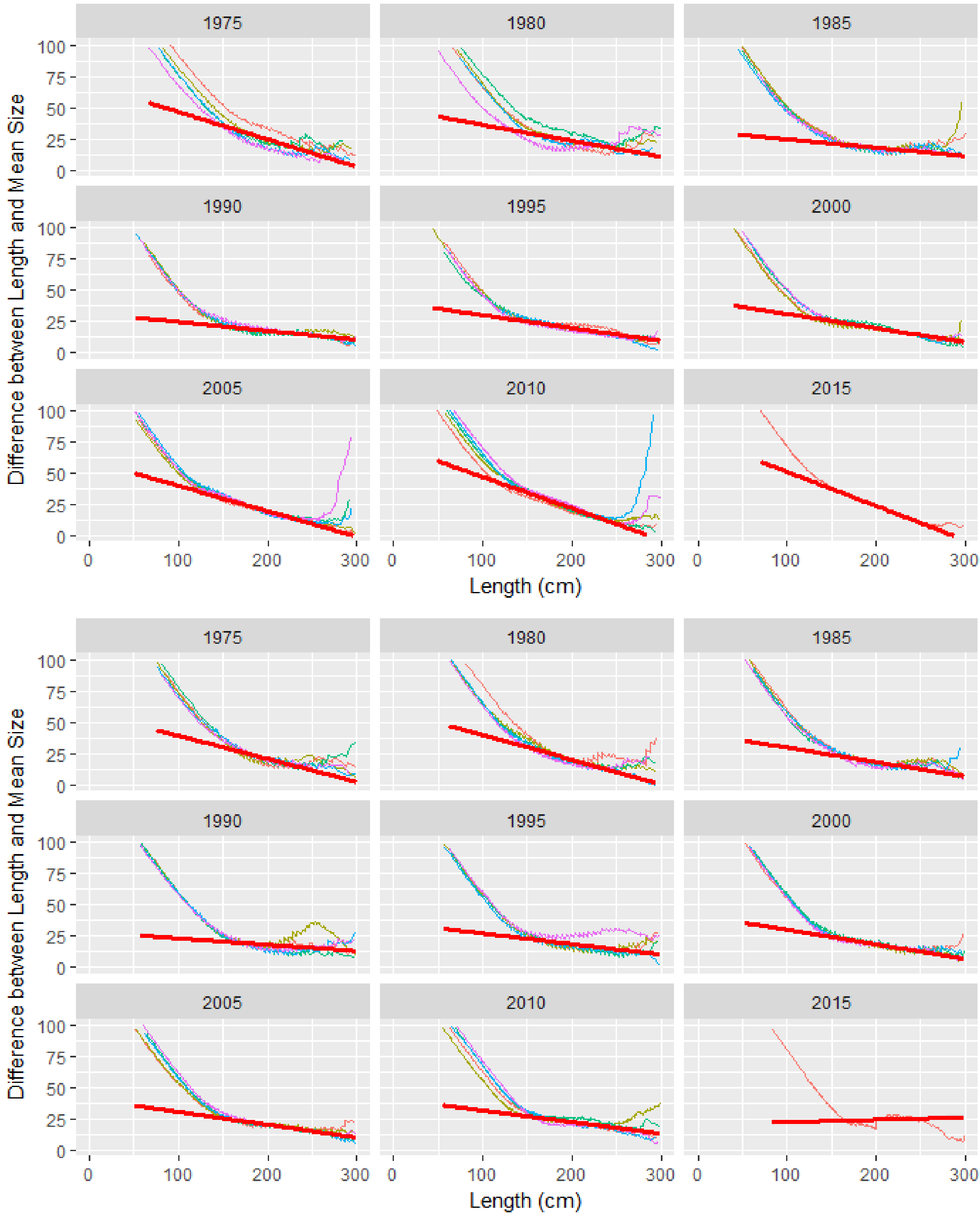

Figure 4. Powell-Wheatherall plots by lustrum for north (top) and south (bottom) Atlantic Swordfish stocks. L′ ranges from 150 to 250 cm.

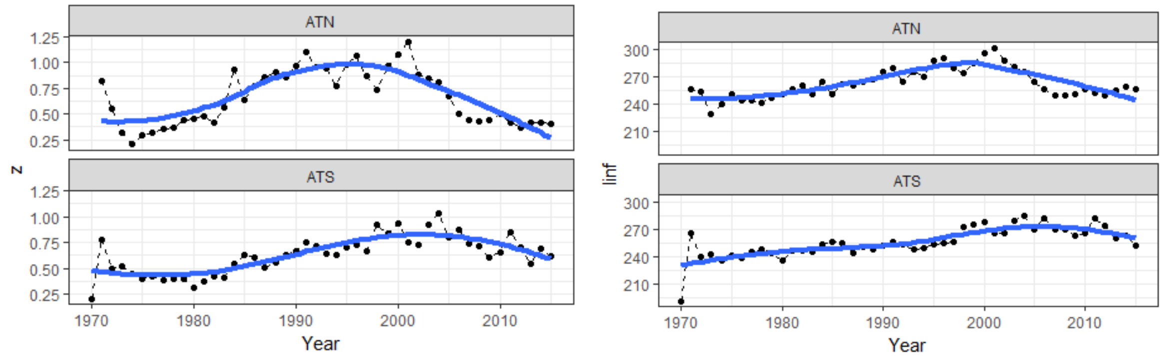

Figure 5. Estimates of Z (left) derived from the Powell-Wetherall plots and L_{inf} (right); showing the estimates from each year (points with hatched line) and a smoother (blue continuous line). Natural mortality is fixed at 0.14 and L′ ranges from 150 to 250 cm.

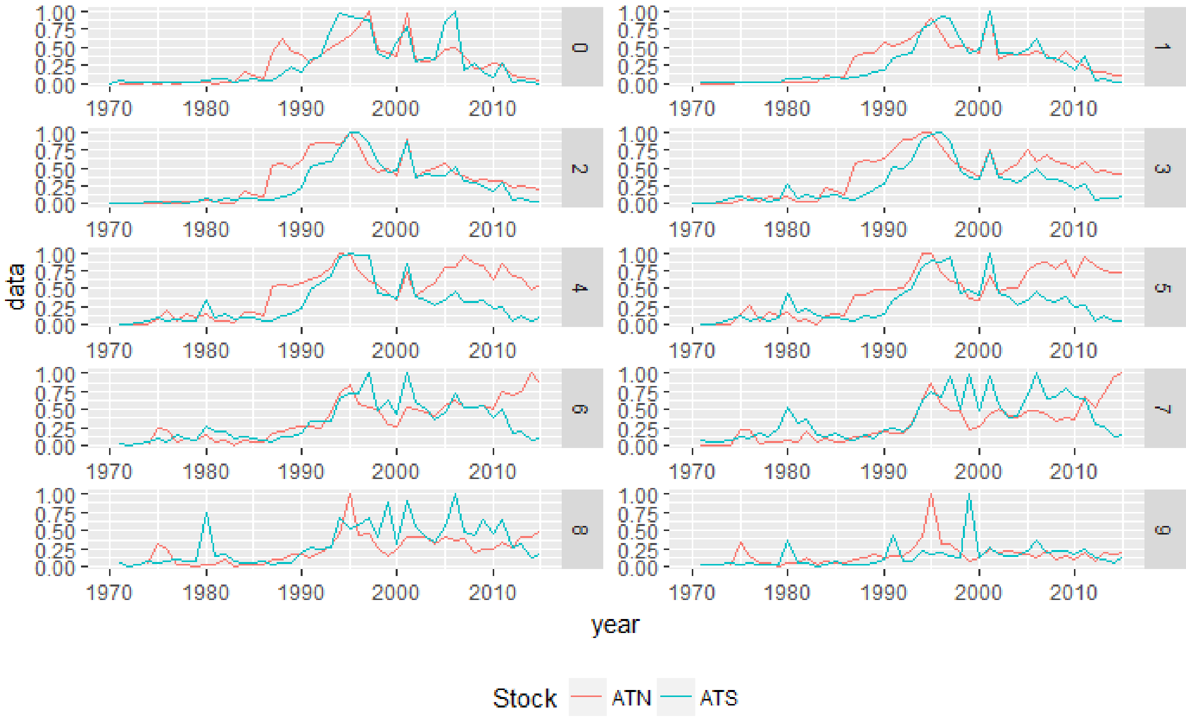

Figure 6. A comparison of the fraction at age using sliced data from north and south Atlantic Swordfish fisheries. Numbers at age are relativized using the series maximum.

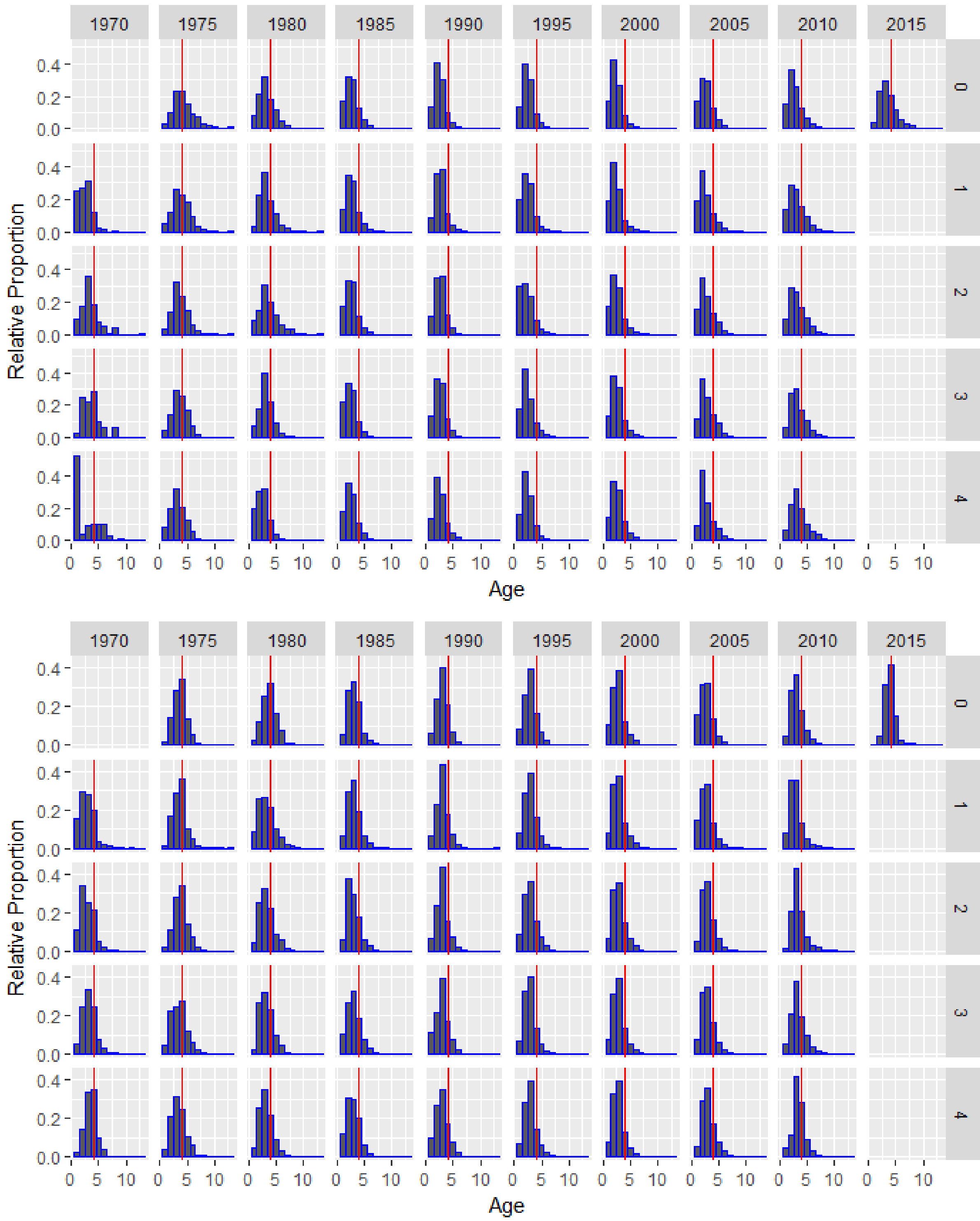

Figure 7. North (top) and south (bottom) Atlantic Swordfish numbers at age. The reference line is drawn at age 4 which according to some is the age at maturity.

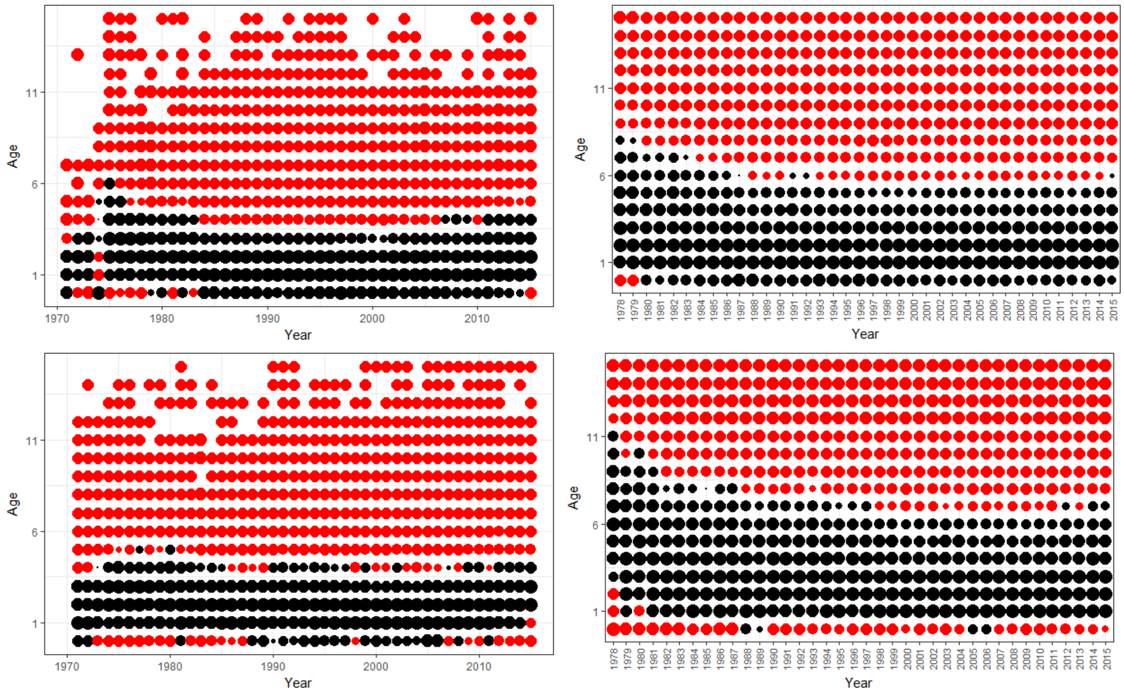

Figure 8. Standardised residuals of the numbers-at-age for the north (top row) and south (bottom row) Atlantic Swordfish stocks with a contrast in age assignment using cohort slicing (right side) and the inverse von Bertalanffy (left side).

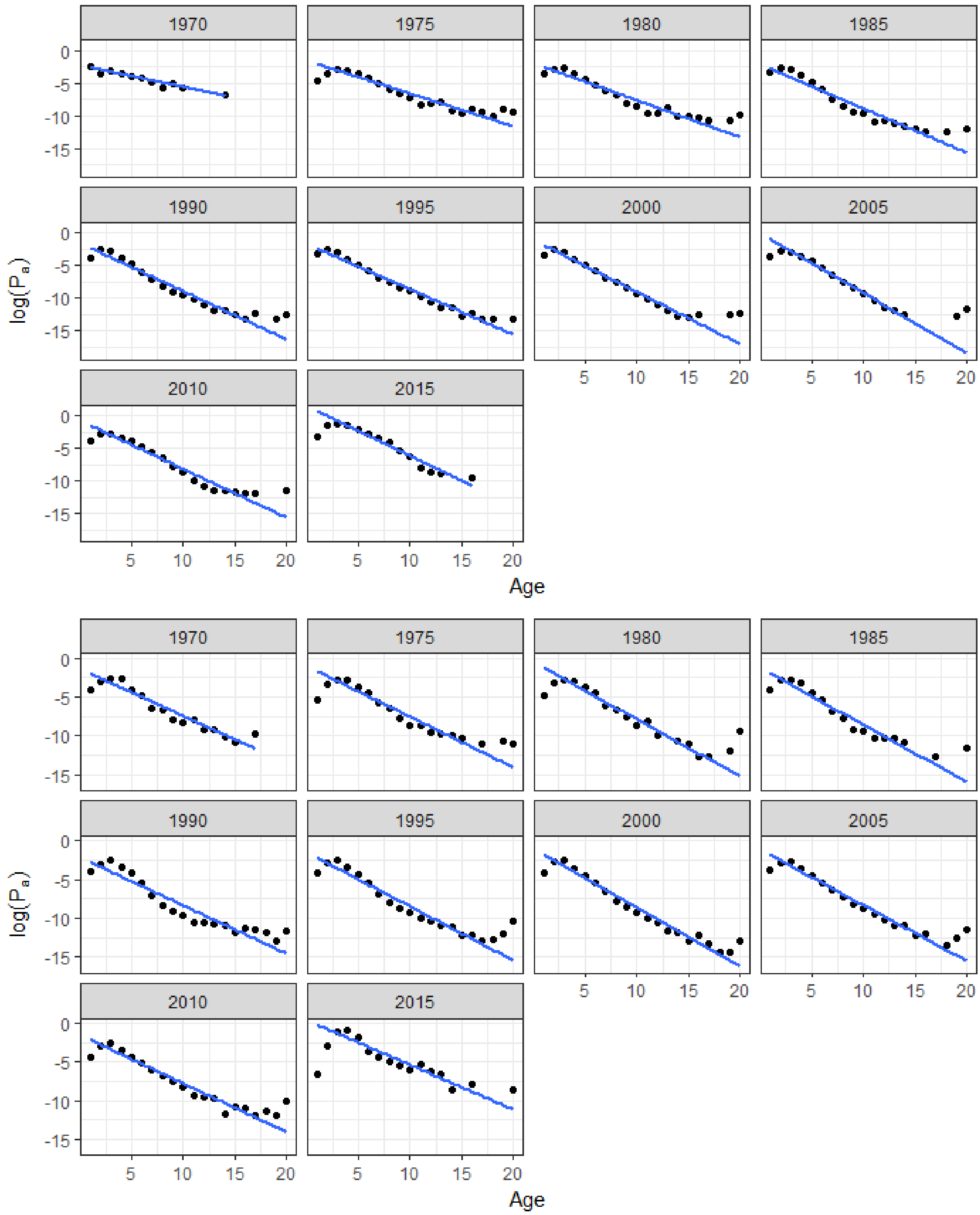

Figure 9. Catch curves based on cohort slicing for north (top) and south (bottom) Atlantic Swordfish stocks by lustrum from the age composition of the catch at length data. Fits to the catch curve are for ages 3 to 9 and are assume constant parameters.

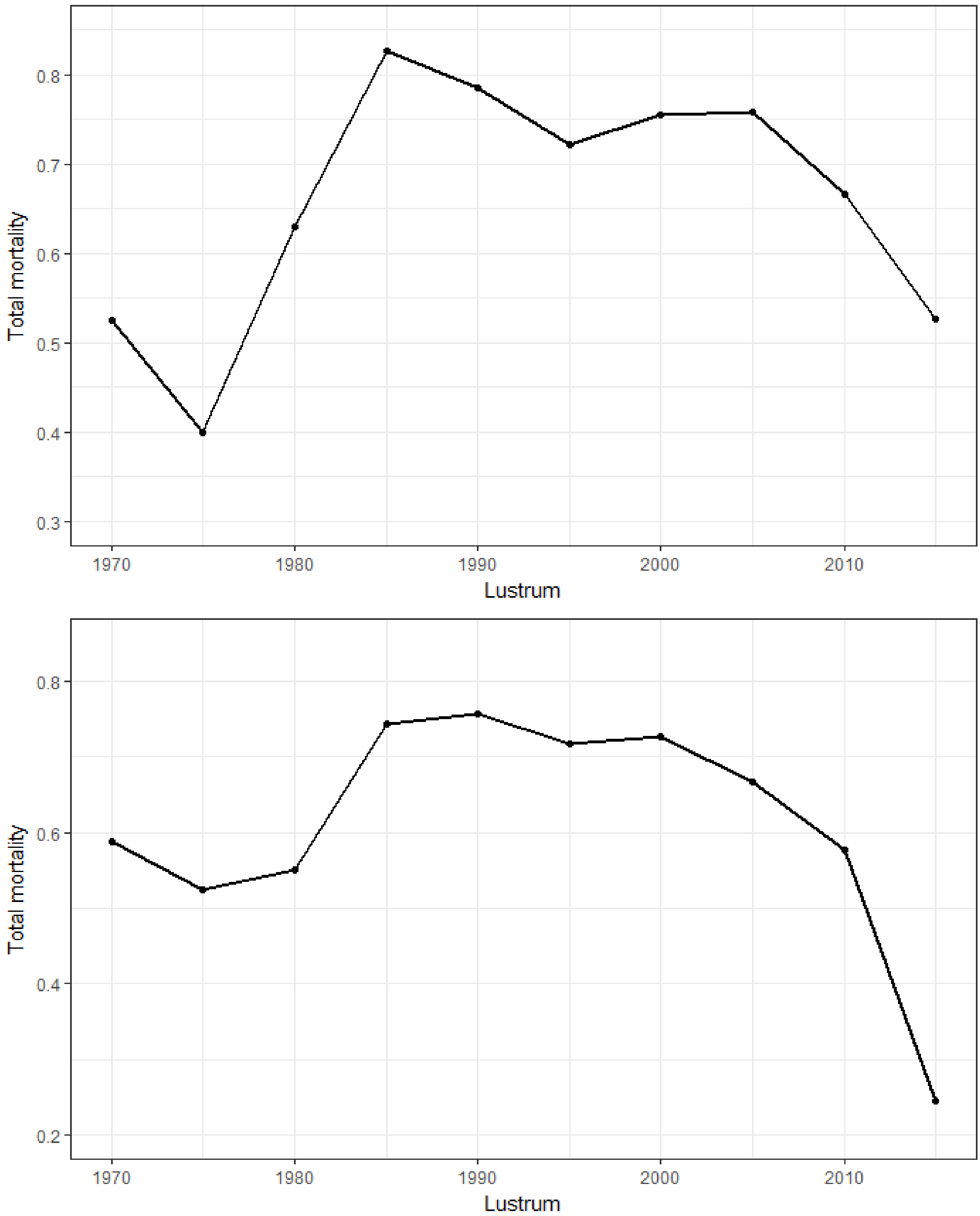

Figure 10. Estimates of Z by lustrum for the north (top) and south (bottom) Atlantic Swordfish stocks. Estimates are from the linear fit to catch curves based on age composition data produced by cohort slicing. Catch curves calculations assume constant parameters and the fit is for ages 3 to 9.

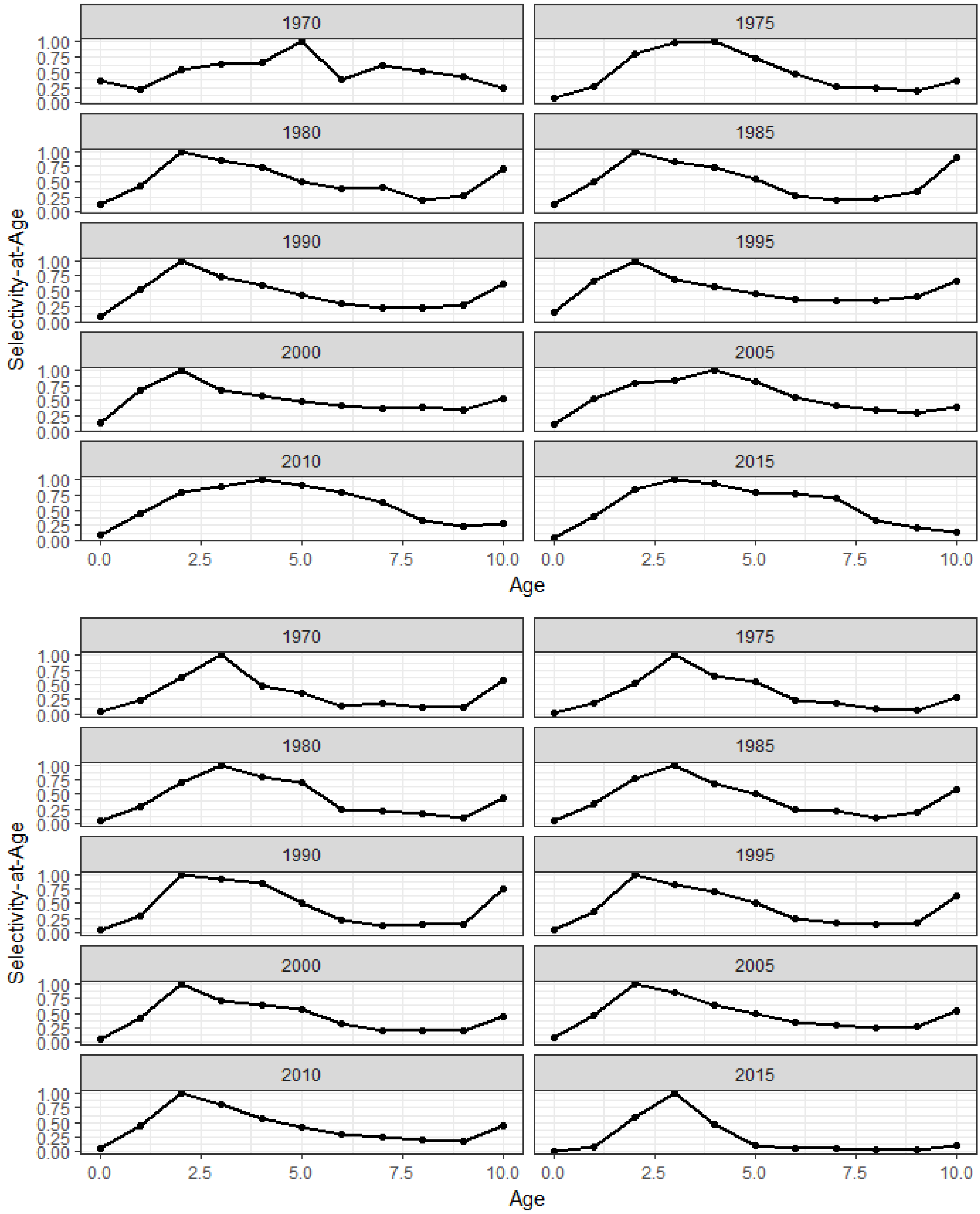

Figure 11. Selectivity at age for the north (top) and south (bottom) Atlantic Swordfish stocks by lustrum. Estimates are from the linear fit to catch curves based on age composition data produced by cohort slicing. Catch curves calculations assume constant parameters.

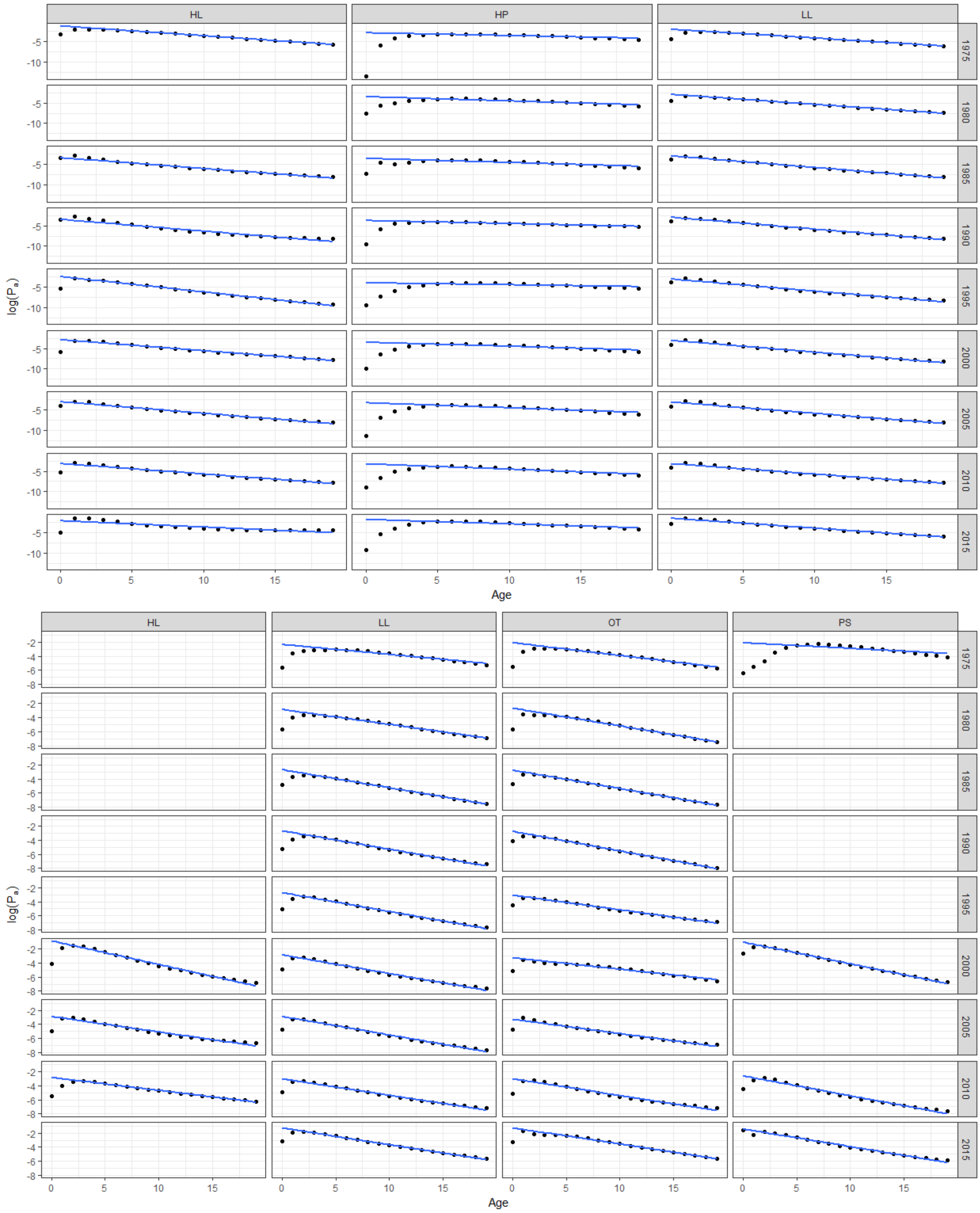

Figure 12. Catch curves based on cohort slicing by gear and lustrum for north (top) and south (bottom) Atlantic Swordfish. Fits to the catch curve are for ages 3 to 9 and are assume constant parameters. Slicing was applied to an updated Task II data set which contained changes to assignments of samples to gear.

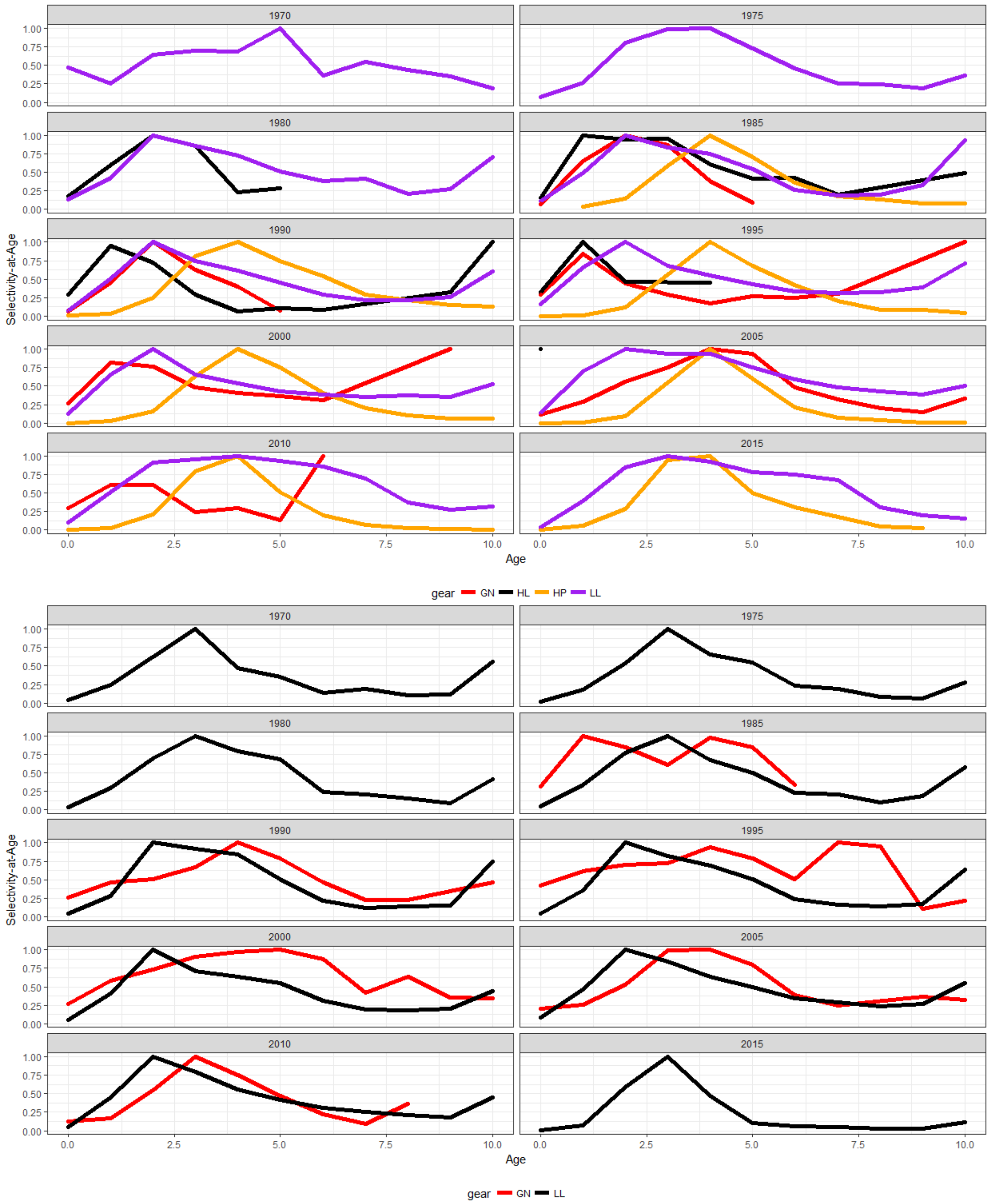

Figure 13. Selectivity at age by gear and lustrum for the north (top) and south (bottom) Atlantic Swordfish stocks where age assignment was based on the inverse von Bertalanffy growth equation. Estimates are from the linear fit to catch curves based on age composition data.

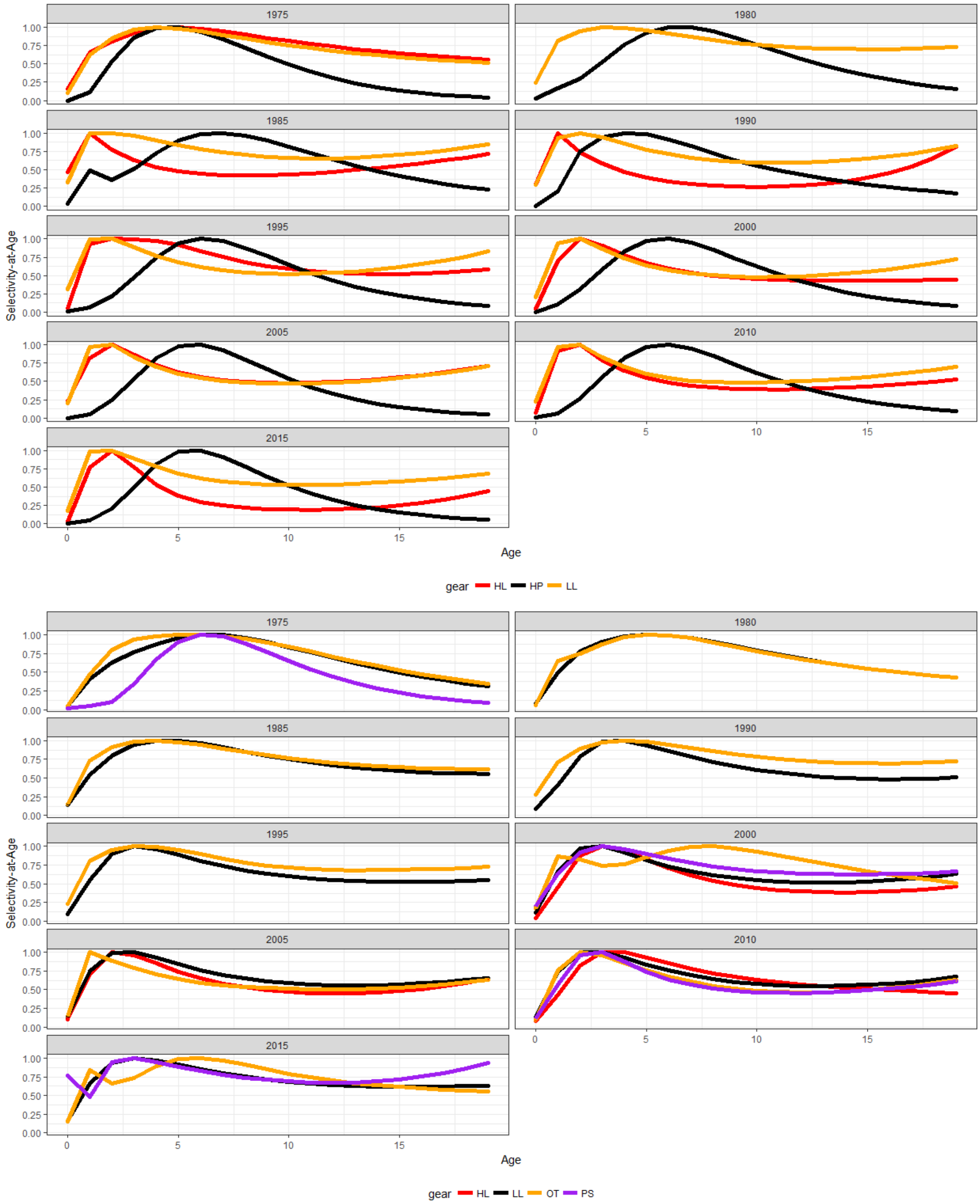

Figure 14. Selectivity at age by gear and lustrum for the north (top) and south (bottom) Atlantic Swordfish stocks where age assignment was based on cohort slicing. Estimates are from the linear fit to catch curves based on age composition data. Slicing was applied to an updated Task II data set which contained changes to assignments of samples to gear.

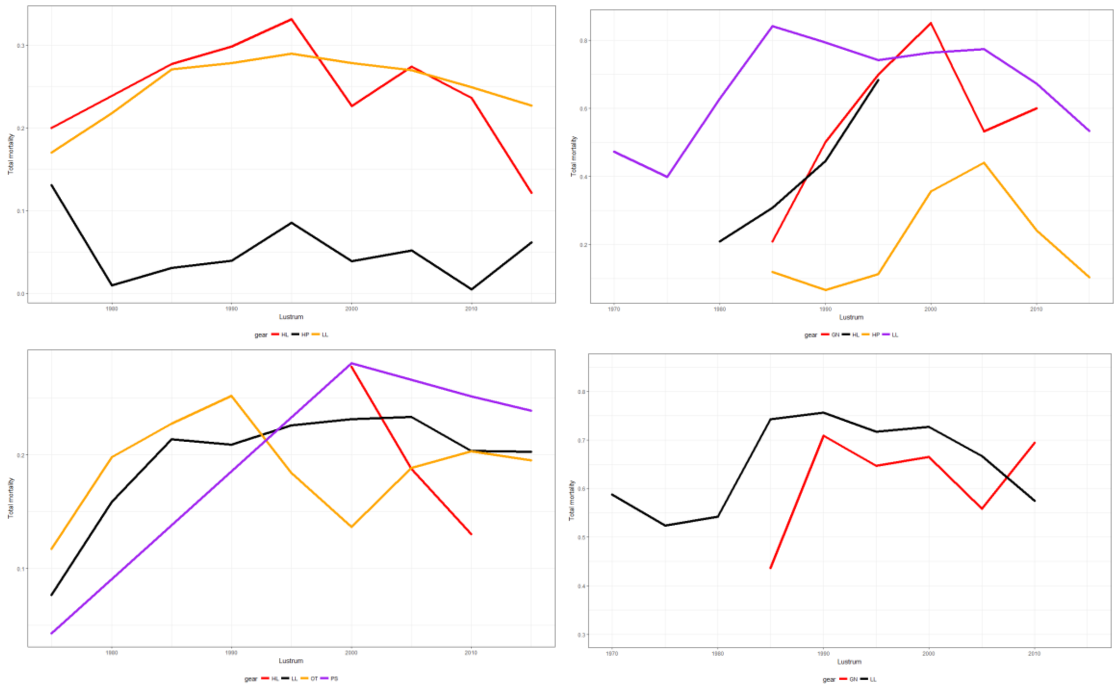

Figure 15. Estimates of Z by lustrum and gear for the north (top) and south (bottom) Atlantic Swordfish stocks. Estimates are from the linear fit to catch curves based on age composition data using the inverse von Bertalanffy (right) and cohort slicing (right). Catch curves calculations assume constant parameters and the fit is for ages 3 to 9. Slicing was applied to an updated Task II data set which contained changes to assignments of samples to gear.