CPUE standardization of bigeye and yellowfin tuna caught by Korean tuna longline fishery in the Indian Ocean

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Abstract

In this study we used generalized linear models (GLM) to standardize operational data from Korean tuna longline fisheries in the Indian Ocean to produce CPUE indices for bigeye and yellowfin tuna. The data used for the GLMs were catch (number), effort (number of hooks), number of hooks between floats (HBF), fishing location (5° cell), vessel identifier, and year-quarter. Data were analyzed separately by region. We applied cluster analysis to address concerns about target species change through time. The CPUE was standardized using lognormal constant and delta lognormal approaches, both with and without vessel effects, with the main indices provided by the delta lognormal approach.

Introduction

The Korean tuna longline fishery in the Indian Ocean commenced in 1957, and from the beginning its target species were bigeye, yellowfin and albacore tunas. The catches of bigeye and yellowfin considerably increased from the mid-1960s, peaking at about 33 thousand tons in 1978 and 31 thousand tons in 1977, respectively, but decreasing to a few hundred tons by the early 2010s. Recently yellowfin catch has increased to around 15 hundred tons, with bigeye catch around 300 hundred tons.

In this study, CPUE (catch per unit effort) standardization of bigeye and yellowfin tuna caught by Korean tuna longline fisheries in the Indian Ocean was conducted using the approaches developed by the collaborative study on tropical tuna CPUE from multiple Indian Ocean longline fleets.

Data and Method

For the CPUE standardization, set by set data were used, which were compiled by vessel captains and reported catch (number of fishes), effort (number of hooks) and HBF (number of hooks between floats) by year, month and area from 1977 to 2018. Data preparation and analysis were carried out using the approaches described by Hoyle et al. (2015, 2016).

The region definitions for bigeye and yellowfin CPUEs are based on the current regional structure (regB2 for bigeye and regY for yellowfin) and alternative structure (regB3 for bigeye and regY2 for yellowfin) that the western equatorial region is subdivided into two regions (the south area and north area of the equator) (Figs. 1 and 2).

To address target change through time, we clustered all data for each area using the approach applied by Hoyle et al. (2015, 2016), and included the categorical cluster variable in the standardization model. For these analyses we aggregated the data by vessel-month, and calculated proportional species composition by dividing the catch in numbers of each species by catch in numbers of all species in the vessel-month. The data were transformed by centering and scaling, to reduce the dominance of species with higher average catches. And we clustered the data using the hierarchical Ward hclust method and using the kmeans method. In addition, hooks between floats (hbf) was included as a targeting variable.

For the CPUE standardization, two approaches, lognormal constant and delta lognormal were used, considering with vessel effects and without vessel effects (see Hoyle et al., 2019). We selected the estimates from the delta lognormal as the main indices.

Results and Discussion

The indices for each region for bigeye and yellowfin are shown in Figs. 3-12, and the indices for the eastern temperate region and others that have a few fishing information are not included in this figure. In tropical areas (regions 1, 2 and 5 for bigeye, and regions 2, 5 and 7 for yellowfin) hbf but not cluster was included as a targeting variable in the model, and in temperate areas (region 3 for bigeye and yellowfin) cluster but not hbf was included as a targeting variable in the model.

For bigeye tuna, the indices prior to 1980 in the tropical areas had very steep decline (Figs. 3, 6 and 17). After that the CPUE in the western tropical region 1 continued to decline at a slower rate until the early 1990s, and then increased to the late 1990s. After this the indices again decreased, but in recent years they showed some increase (Figs. 3 and 17). In the eastern tropical region 2 the indices after 1980 were steady although with large fluctuations (Figs. 6 and 17). In the regB3 structure the western tropical region was split into two subregions, the

south-western part (regB3_R1) and the north-western part (regB3_R5). The indices in regY2_R2 and regY2_R7 showed similar increasing trends, but there was little information in regB3_R5 after 2010 (Figs. 4-5 and 17). In western temperate region 3, prior to 2000 there was relatively little information, and after 2010 the indices have shown an increasing trend (Figs. 7 and 17).

For yellowfin tuna, the indices prior to 1980 in the tropical areas also had very steep declines, and continued decline, but showed an increasing trend in the western tropical region 2 in the early 1980s (Figs. 8, 11 and 18). In the regY2 structure the western tropical region was split into two subregions, the south-western part (regY2_R2) and the north-western part (regY2_R7). The indices in regY2_R2 and regY2_R7 showed similar trend but had differences in fluctuation by year (Figs. 9-10 and 18). In western temperate region 3 the pattern showed a decreasing trend and had a large fluctuation (Figs. 12 and 18).

References

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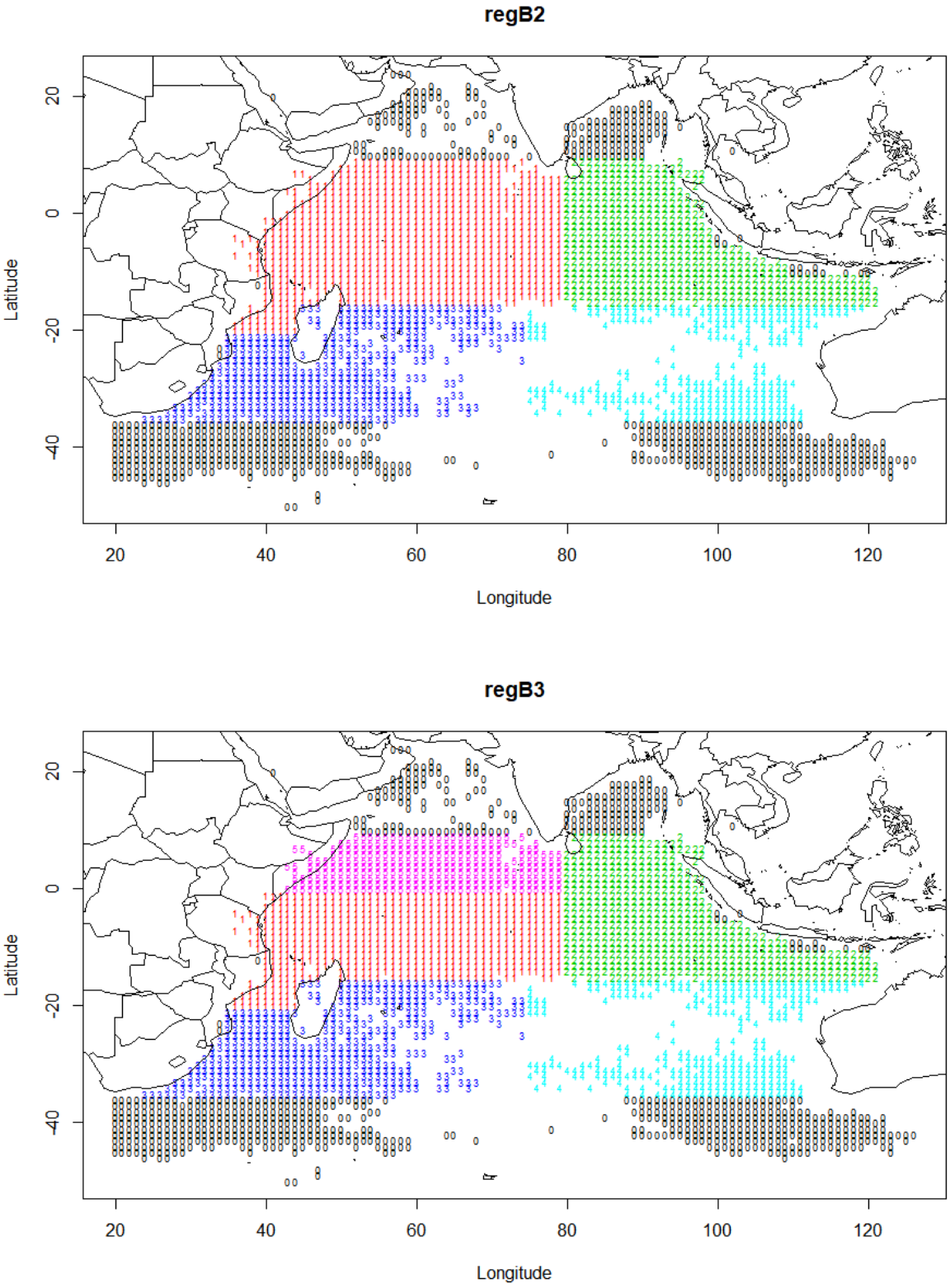

Fig. 1. Maps of the regional structures used to estimate bigeye CPUE indices for the versions in which the western tropical region is contiguous (above) and split (below).

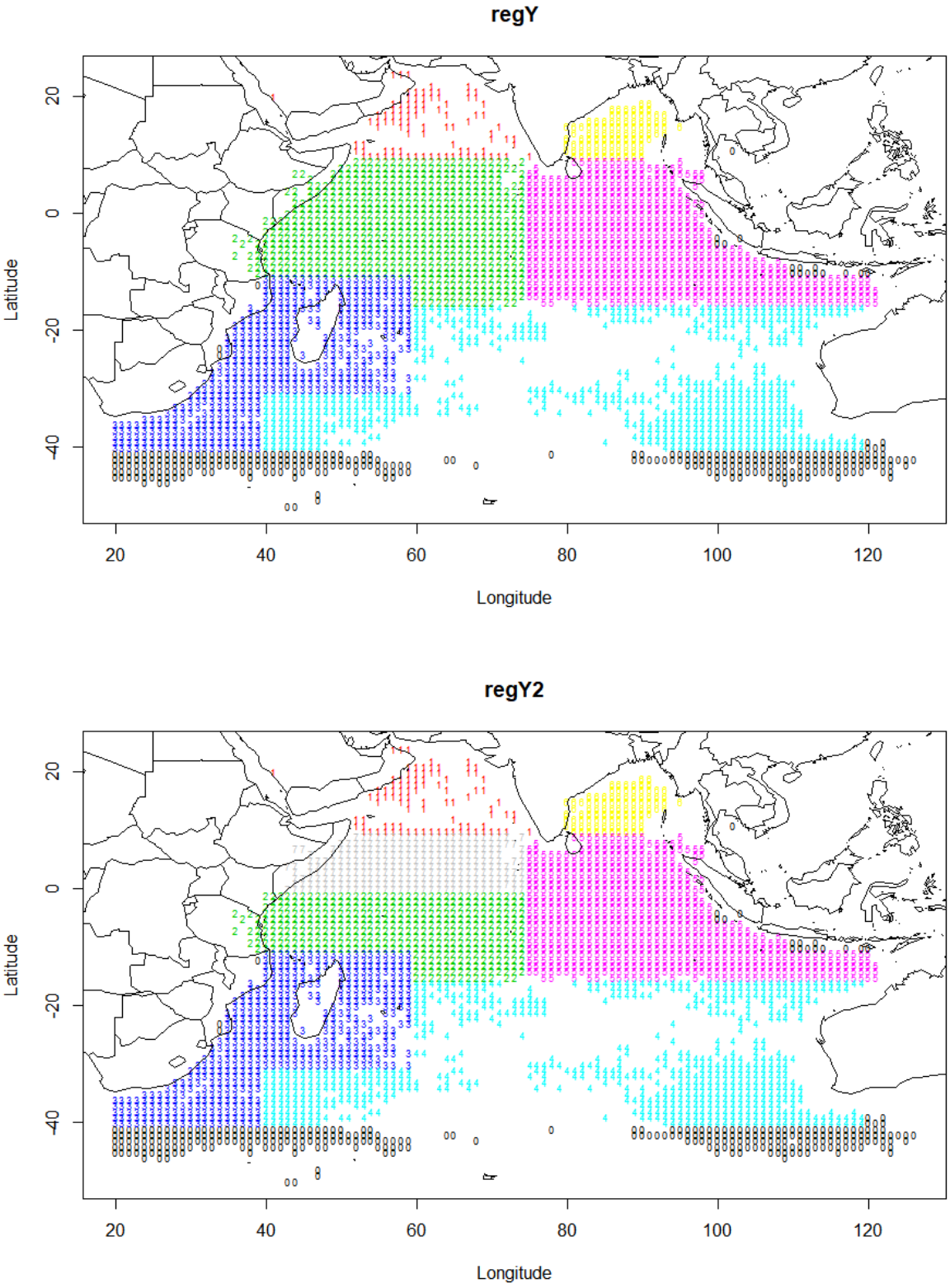

Fig. 2. Maps of the regional structures used to estimate yellowfin CPUE indices for the versions in which the western tropical region is contiguous (above) and split (below).

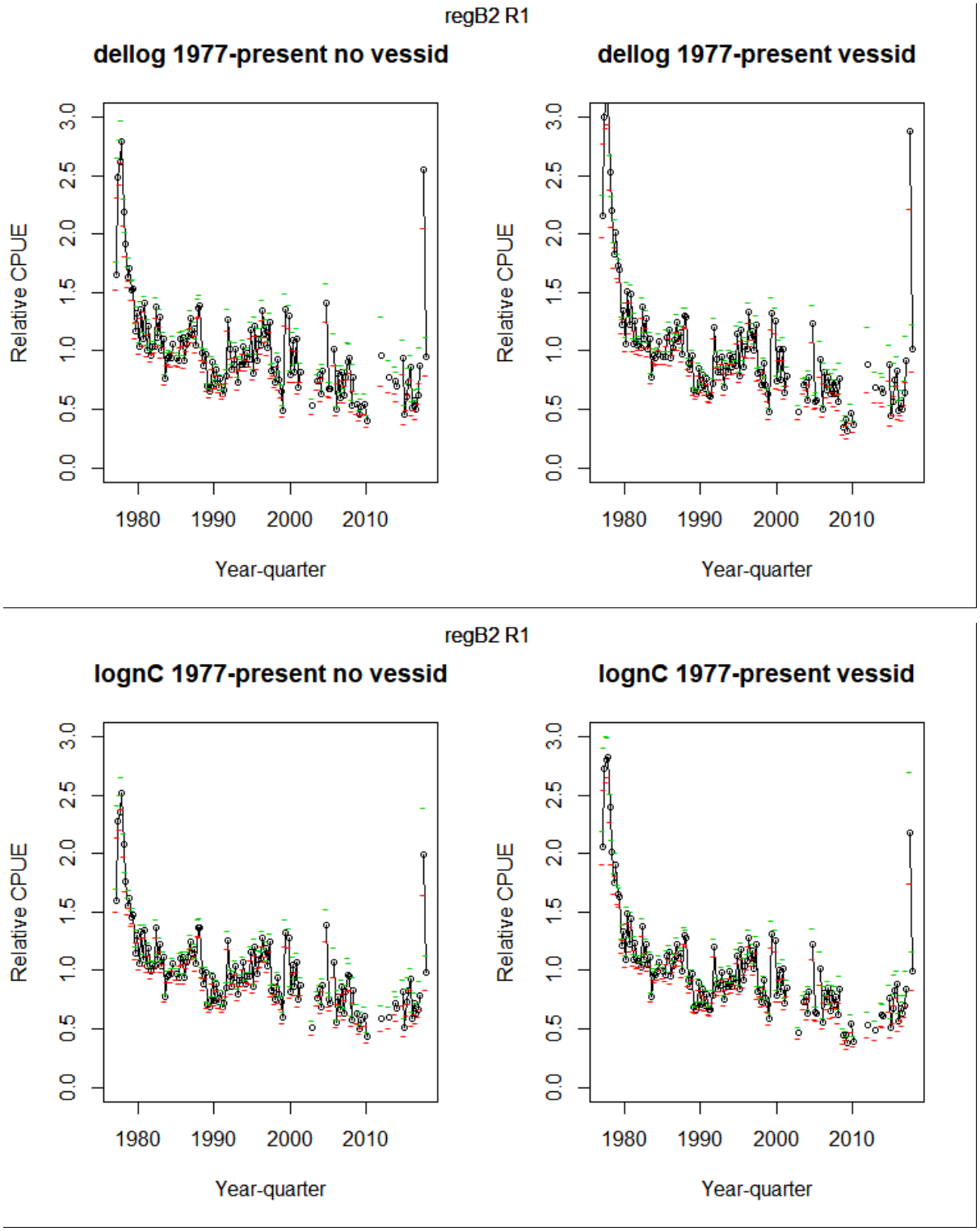

Fig. 3. Quarterly CPUE series for bigeye region 1 (western tropical, regB2_R1). The plots show indices from delta lognormal with (upper right) and without (upper left) vessel effects, and indices for lognormal constant with (lower right) and without (lower left) vessel effects.

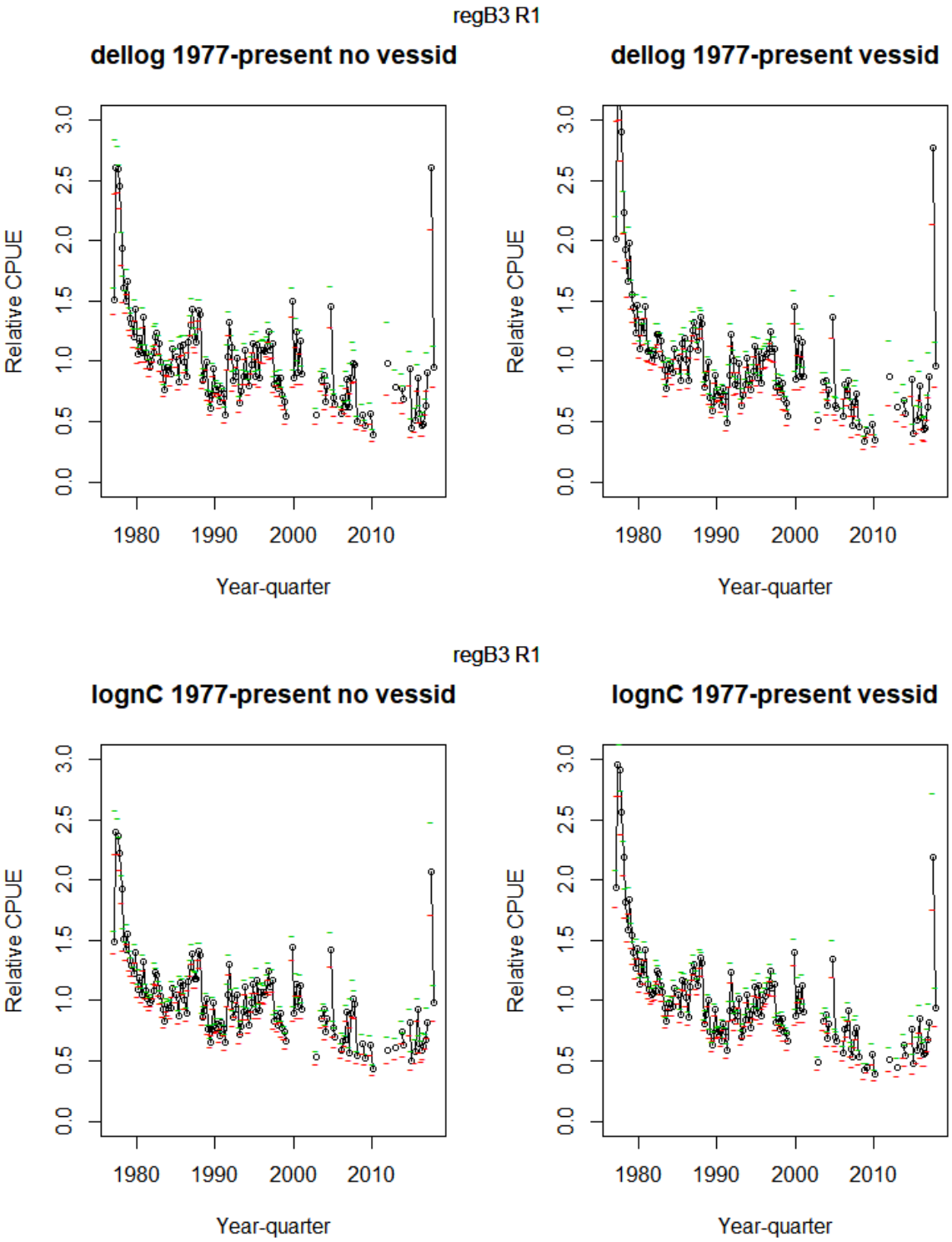

Fig. 4. Quarterly CPUE series for bigeye region 1s (south-western tropical, regB3_R1). The plots show indices from delta lognormal with (upper right) and without (upper left) vessel effects, and indices for lognormal constant with (lower right) and without (lower left) vessel effects.

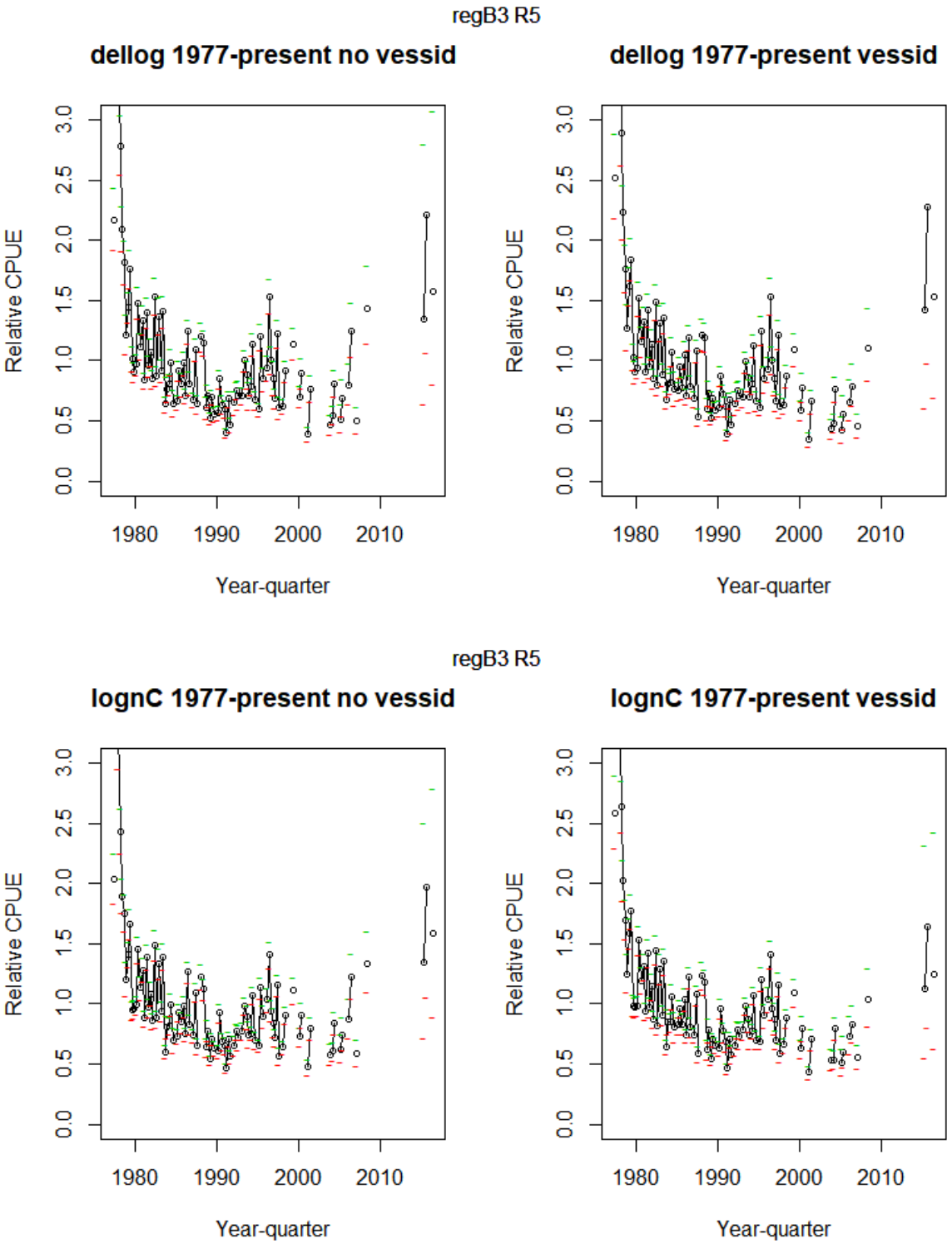

Fig. 5. Quarterly CPUE series for yellowfin region 1n (north-western tropical, regB3_R5). The plots show indices from delta lognormal with (upper right) and without (upper left) vessel effects, and indices for lognormal constant with (lower right) and without (lower left) vessel effects.

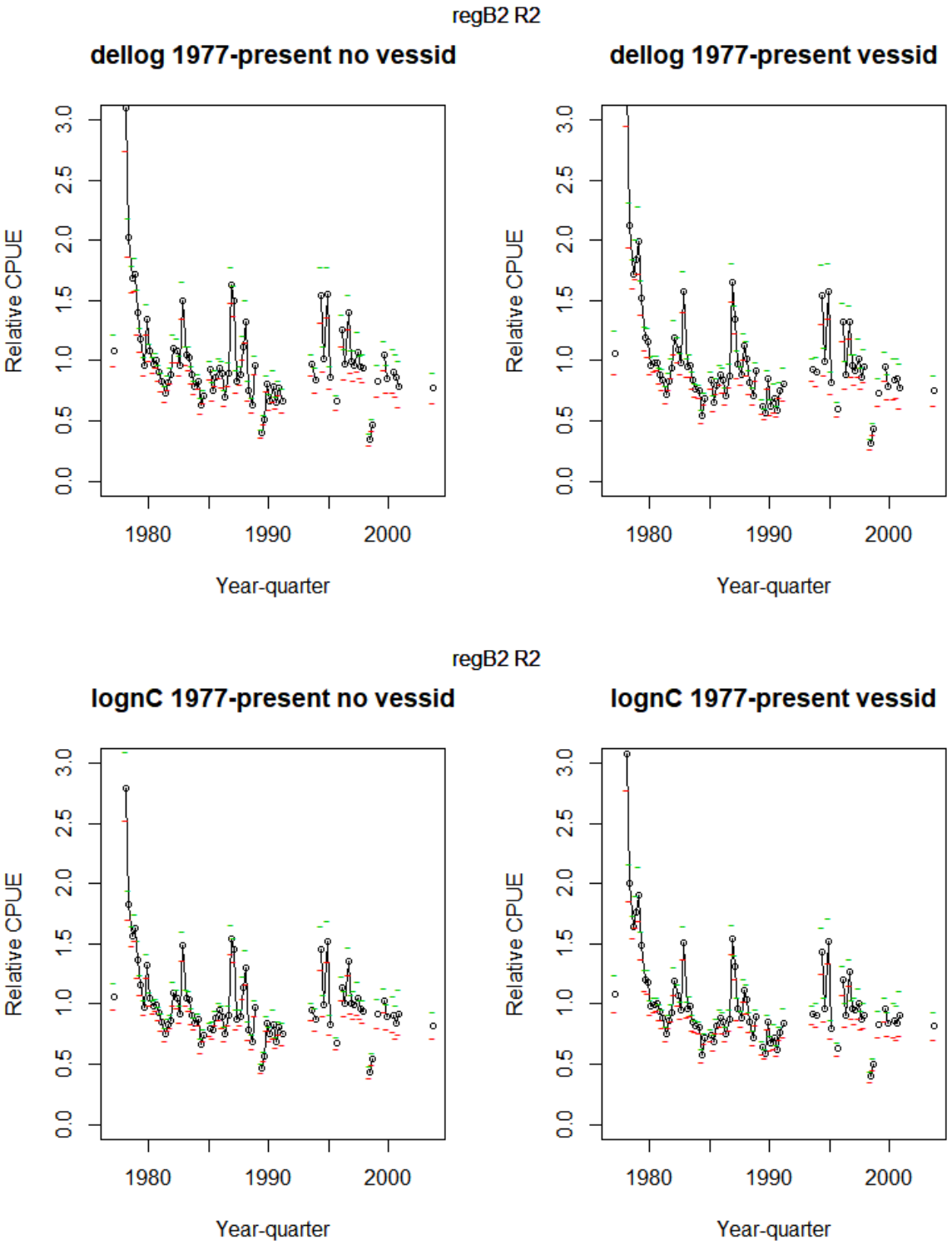

Fig. 6. Quarterly CPUE series for yellowfin region 2 (eastern tropical, regB2_R2). The plots show indices from delta lognormal with (upper right) and without (upper left) vessel effects, and indices for lognormal constant with (lower right) and without (lower left) vessel effects.

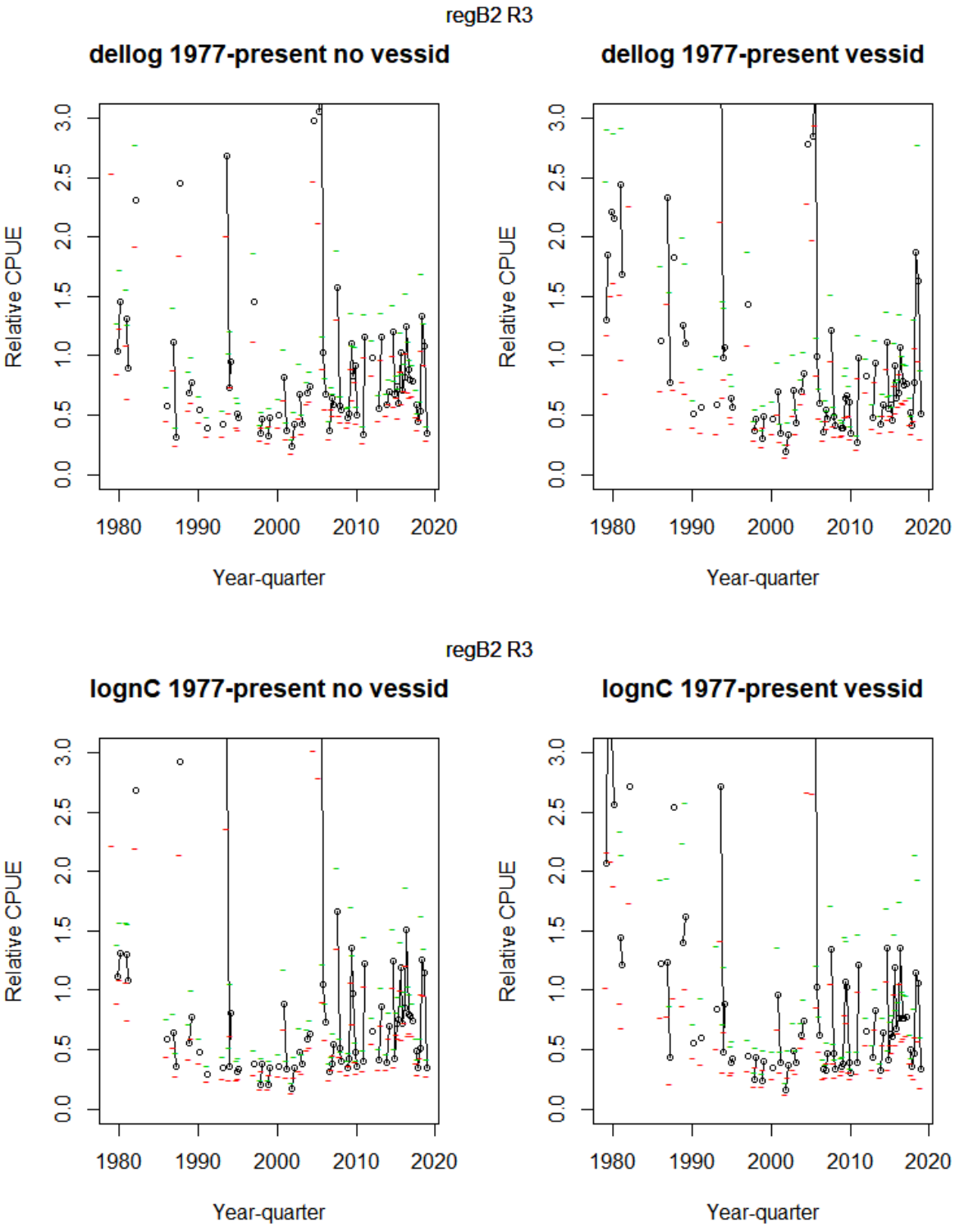

Fig. 7. Quarterly CPUE series for bigeye region 3 (eastern tropical, regB2_R3). The plots show indices from delta lognormal with (upper right) and without (upper left) vessel effects, and indices for lognormal constant with (lower right) and without (lower left) vessel effects.

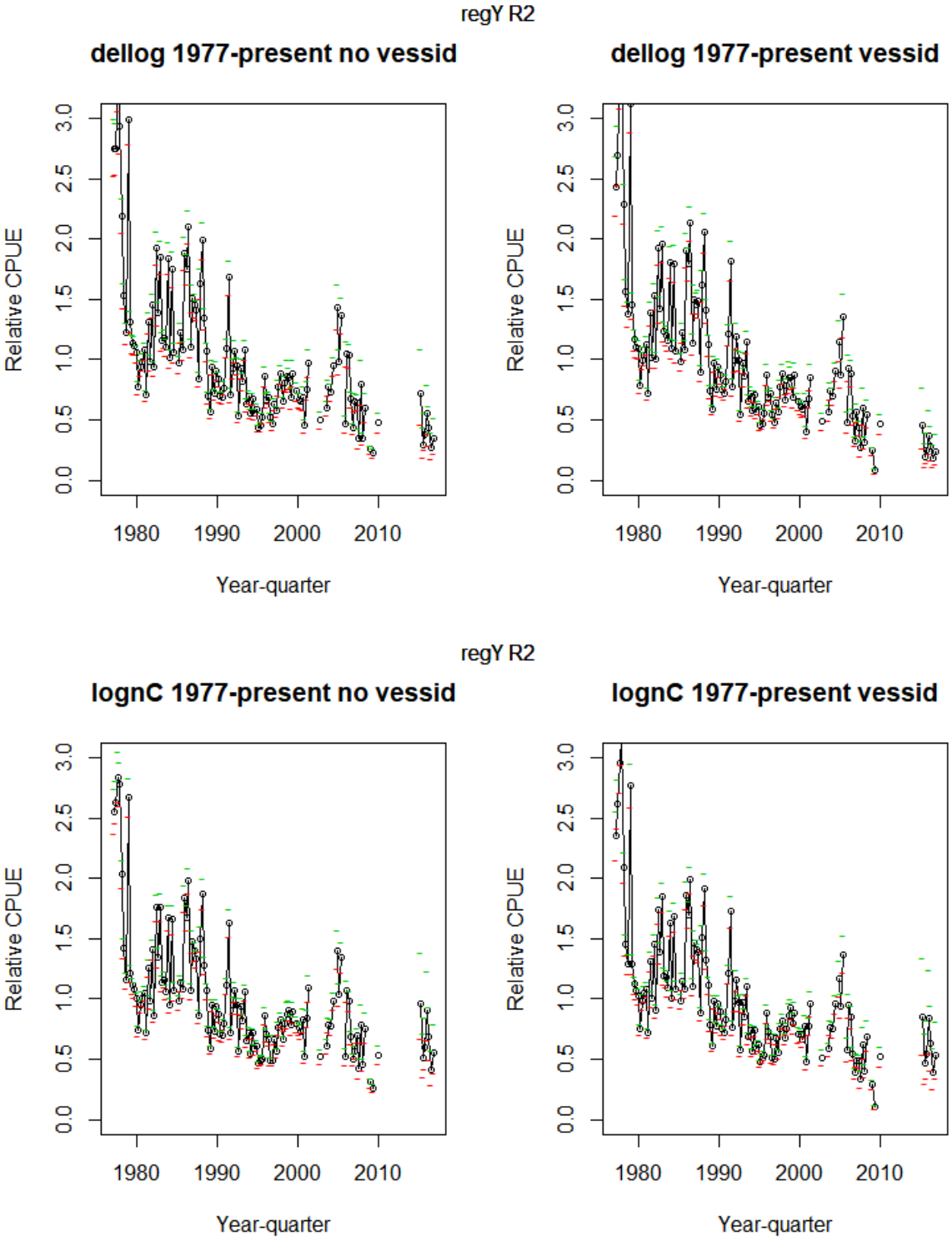

Fig. 8. Quarterly CPUE series for yellowfin region 2 (western tropical, regY_R2). The plots show indices from delta lognormal with (upper right) and without (upper left) vessel effects, and indices for lognormal constant with (lower right) and without (lower left) vessel effects.

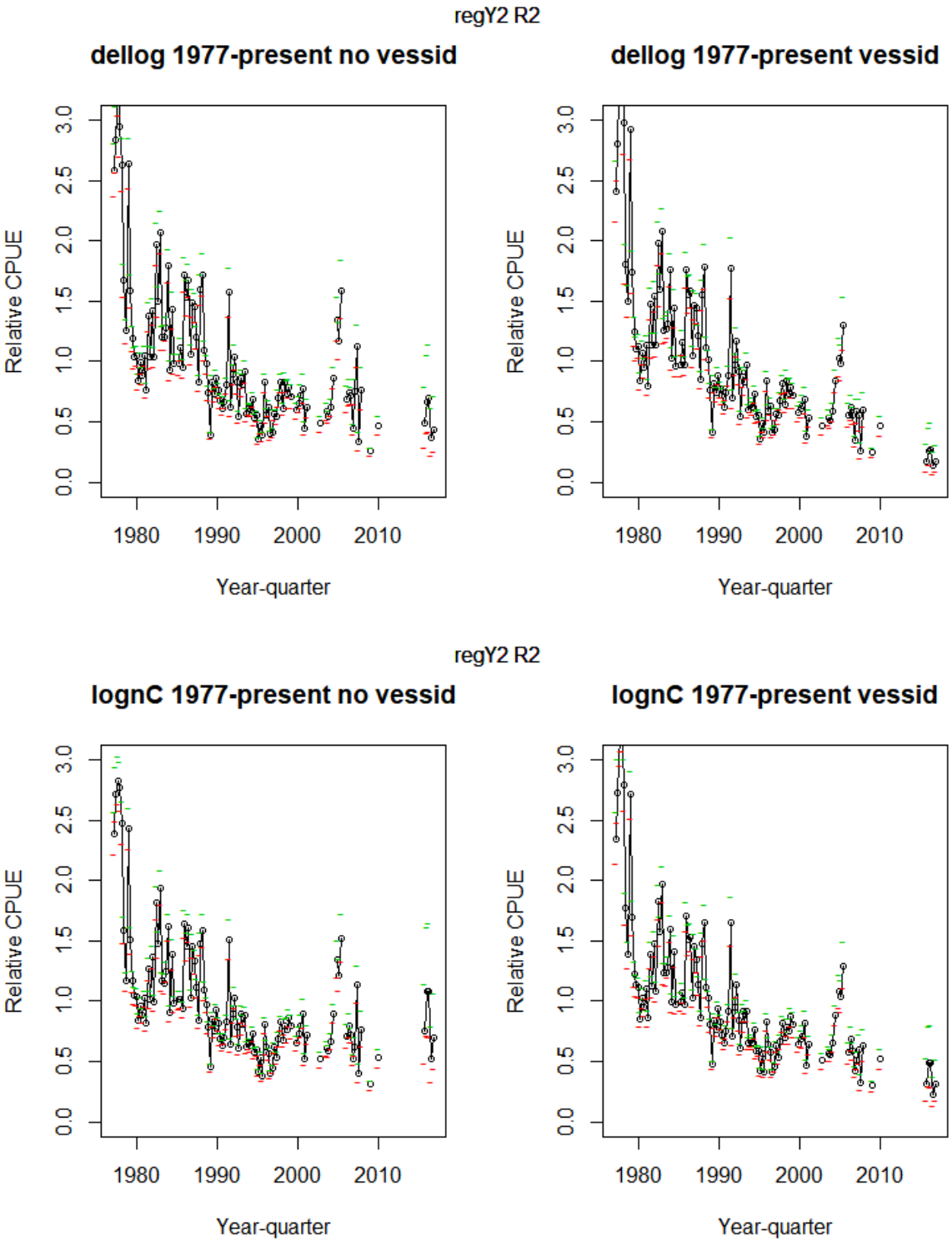

Fig. 9. Quarterly CPUE series for yellowfin region 2s (south-western tropical, regY2_R2). The plots show indices from delta lognormal with (upper right) and without (upper left) vessel effects, and indices for lognormal constant with (lower right) and without (lower left) vessel effects.

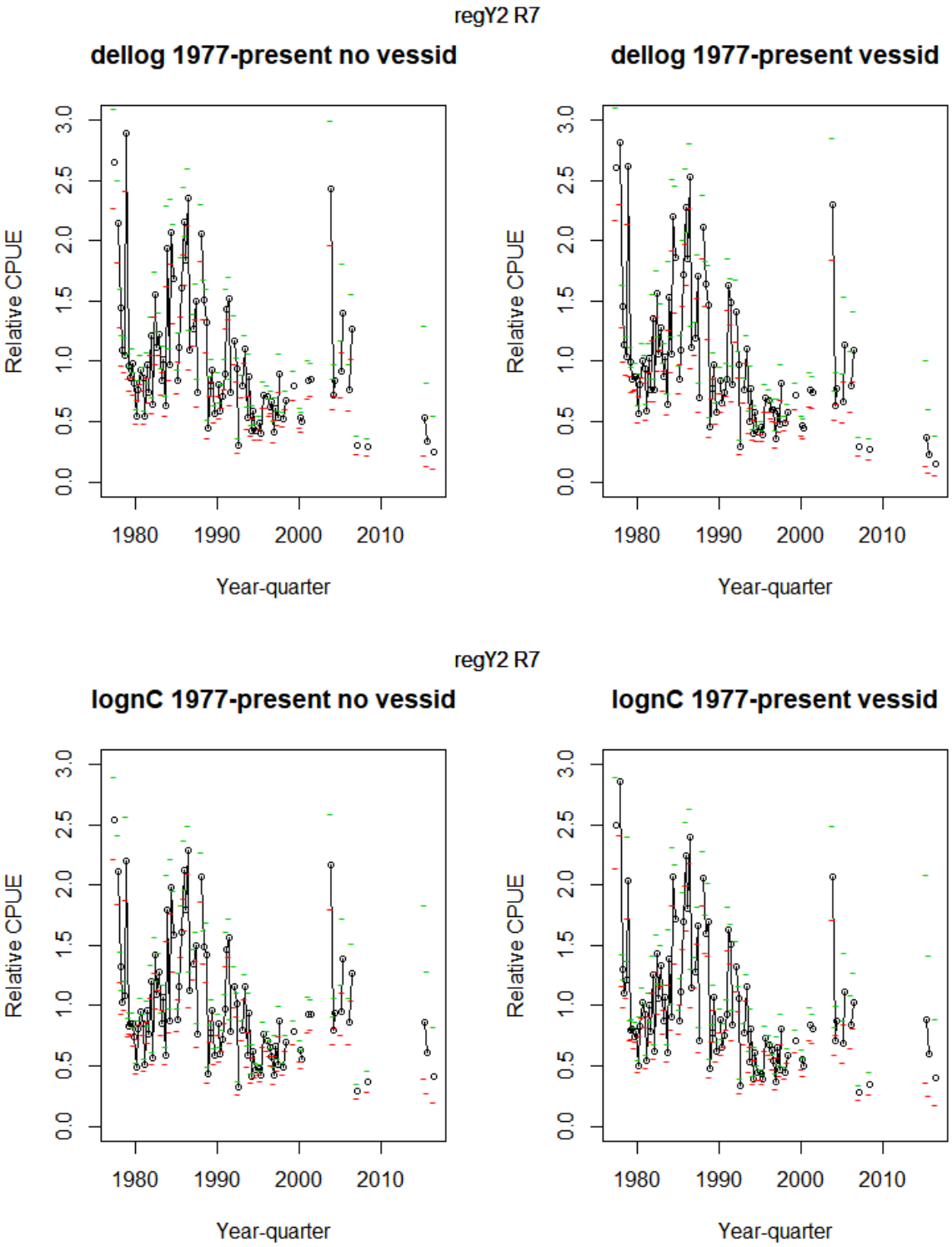

Fig. 10. Quarterly CPUE series for yellowfin region 2n (north-western tropical, regY2_R7). The plots show indices from delta lognormal with (upper right) and without (upper left) vessel effects, and indices for lognormal constant with (lower right) and without (lower left) vessel effects.

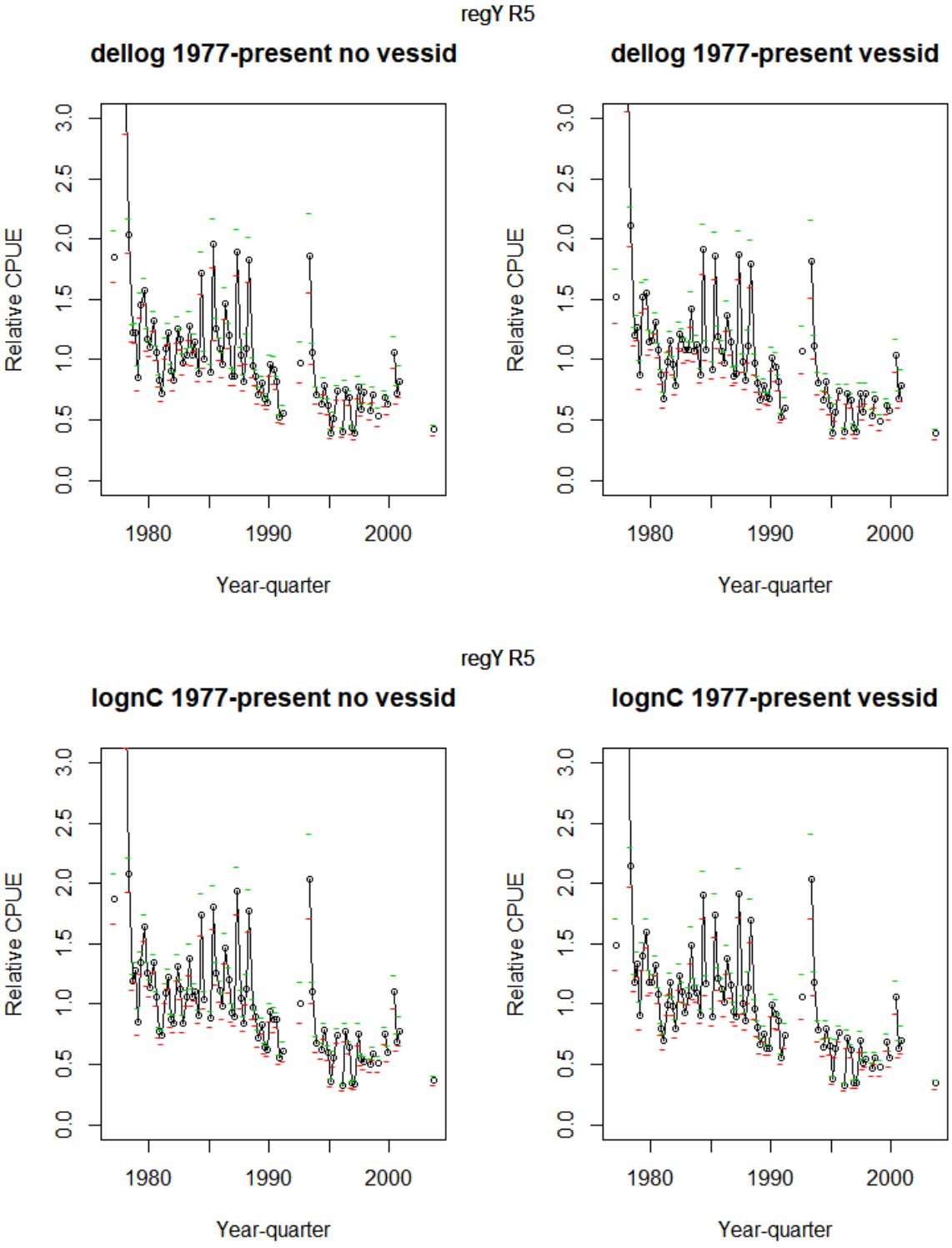

Fig. 11. Quarterly CPUE series for yellowfin region 5 (eastern tropical, regY_R5). The plots show indices from delta lognormal with (upper right) and without (upper left) vessel effects, and indices for lognormal constant with (lower right) and without (lower left) vessel effects.

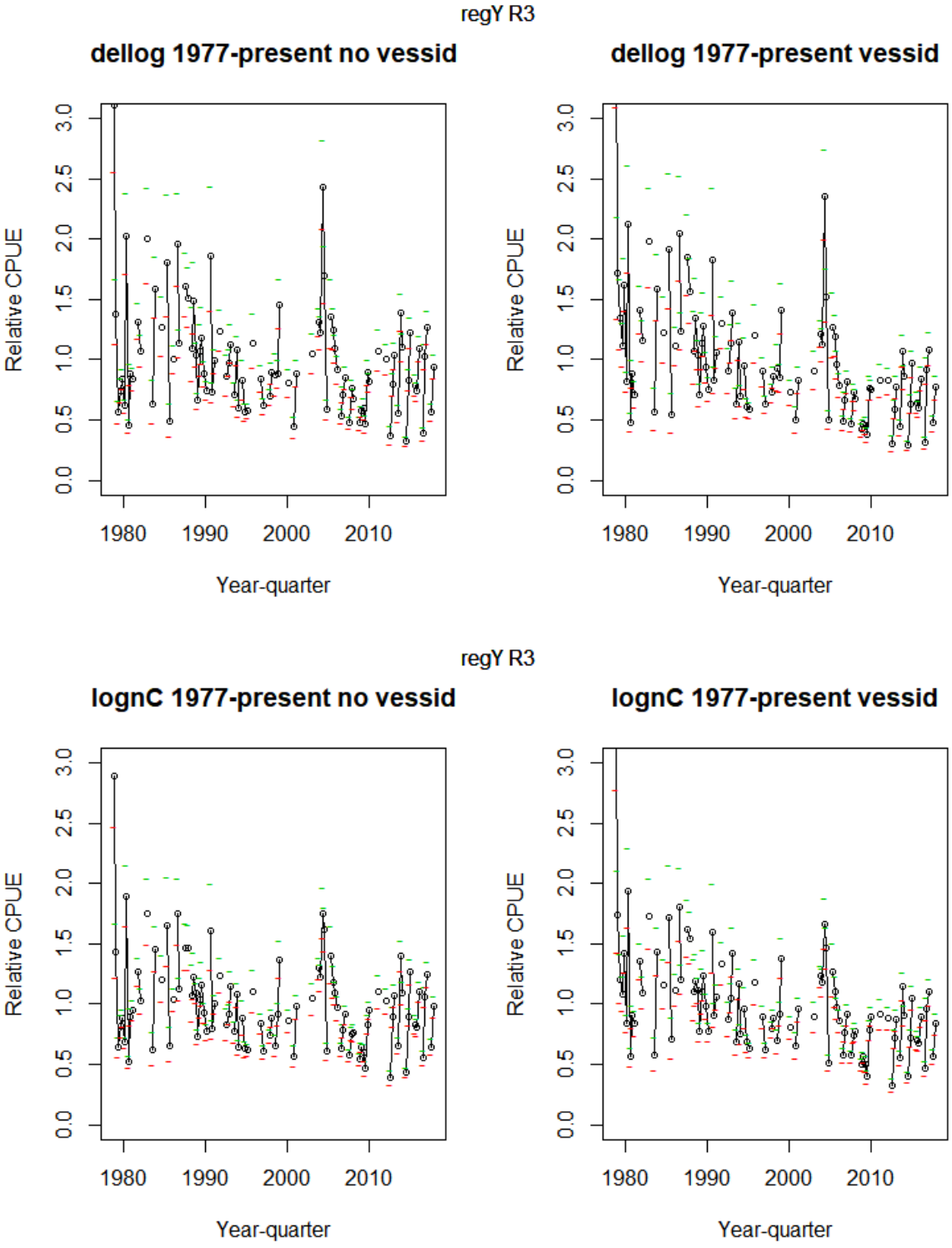

Fig. 12. Quarterly CPUE series for yellowfin region 3 (western temperate, regY_R3). The plots show indices from delta lognormal with (upper right) and without (upper left) vessel effects, and indices for lognormal constant with (lower right) and without (lower left) vessel effects.

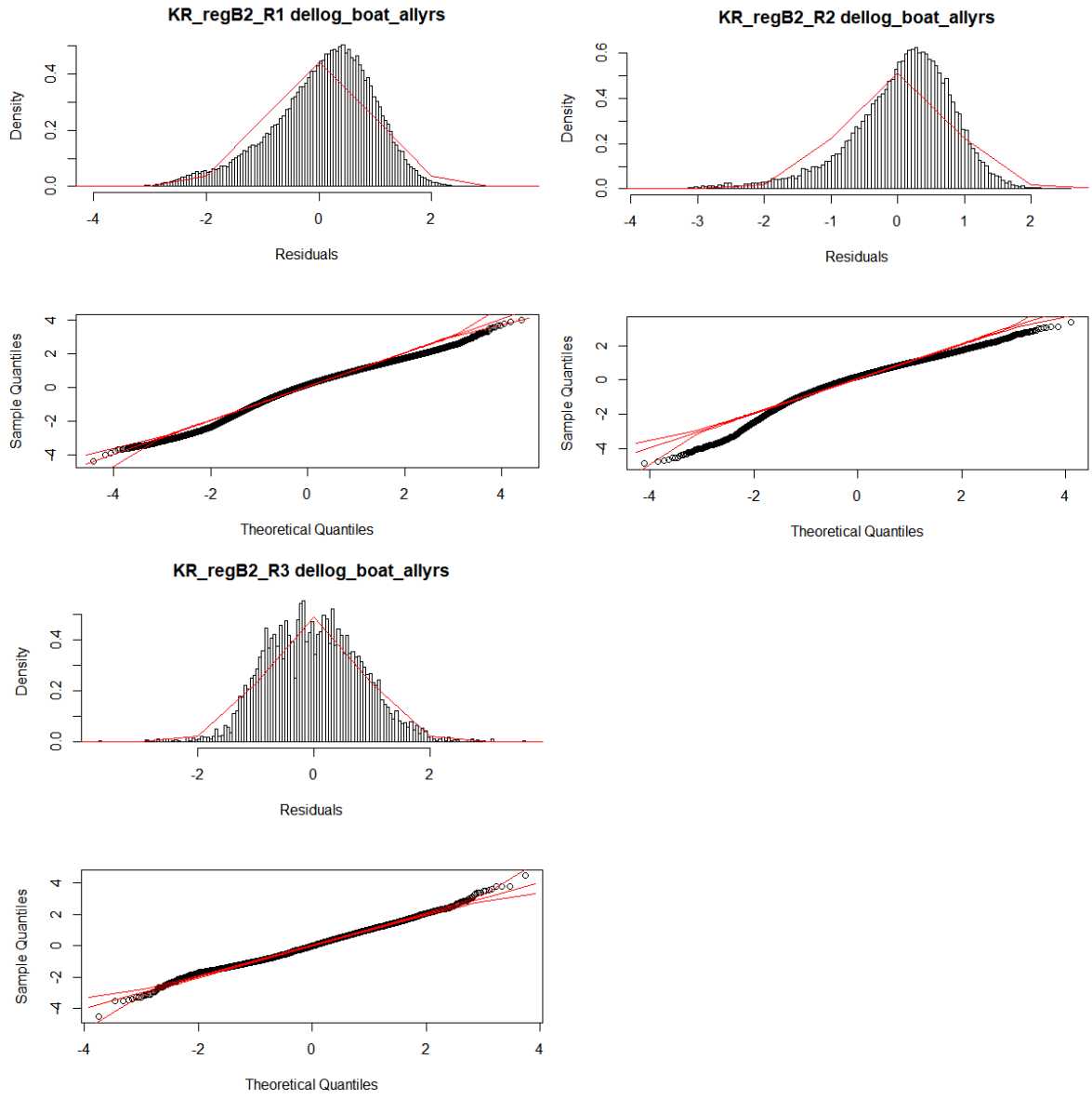

Fig. 13. Diagnostic plots for bigeye delta lognormal model in regions 1, 2 and 3 (regB2_R1, regB2_R2 and regB2_R3) with vessel effects.

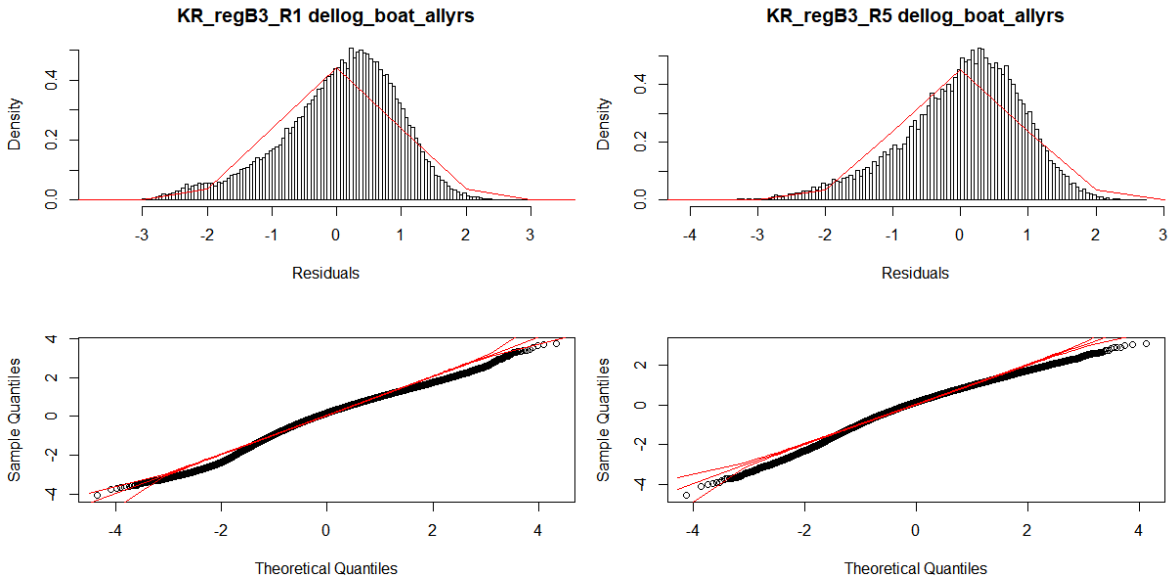

Fig. 14. Diagnostic plots for bigeye delta lognormal model in regions 1s and 1n (regB3_R1 and regB3_R5) with vessel effects.

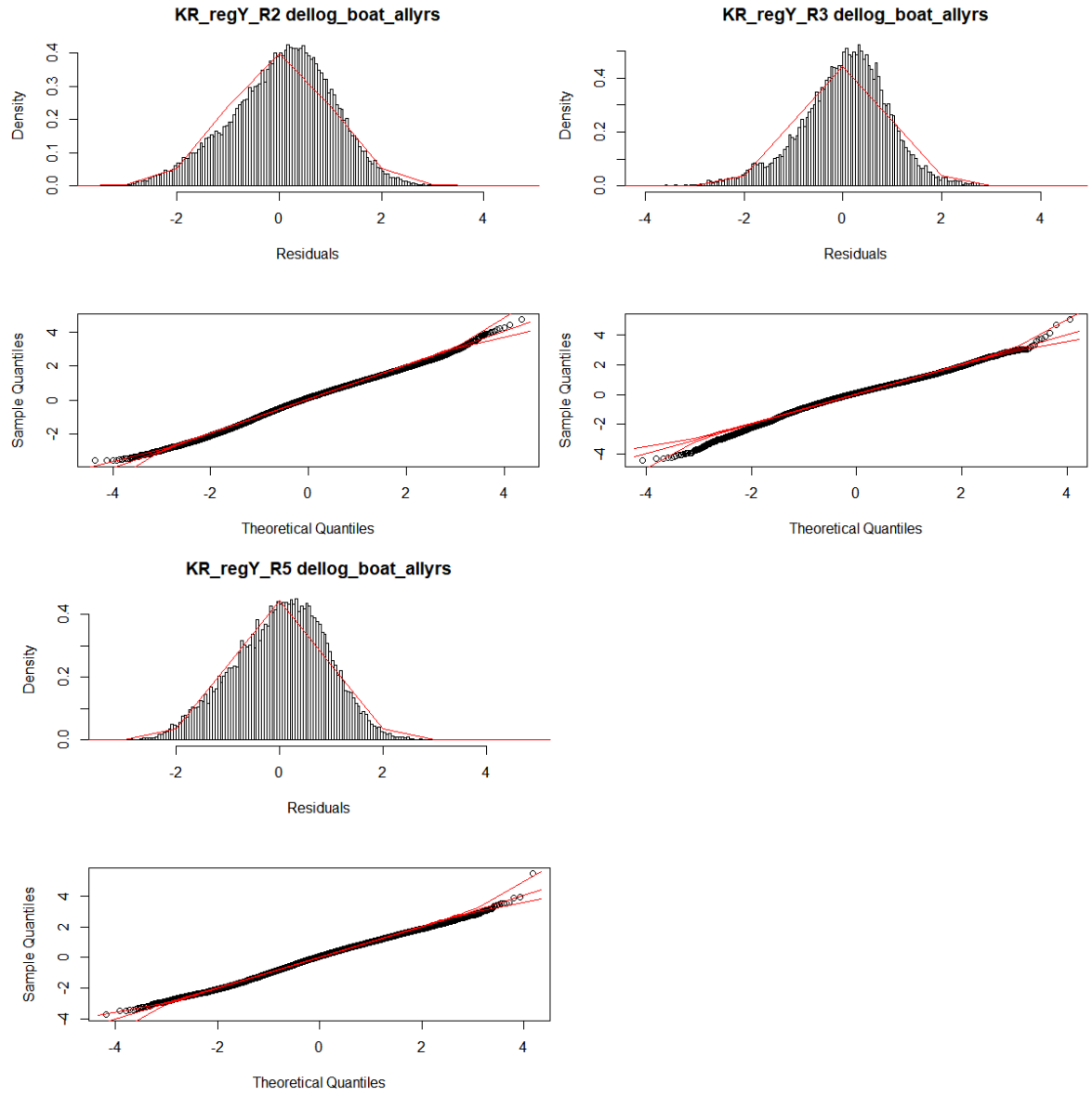

Fig. 15. Diagnostic plots for yellowfin delta lognormal model in regions 2, 3 and 5 (regY_R2, regY_R3 and regY_R5) with vessel effects.

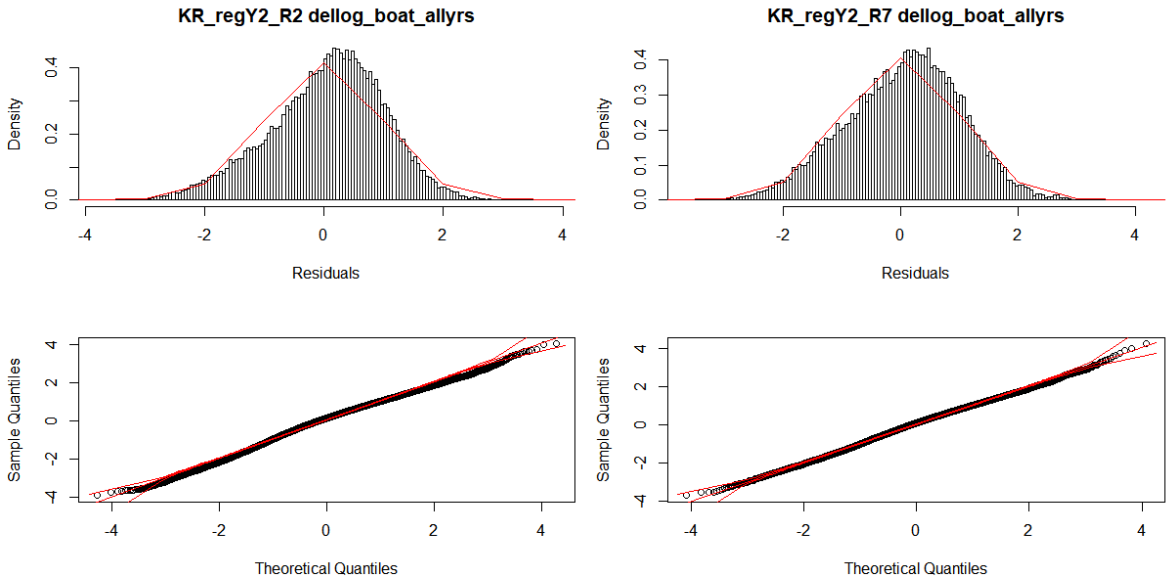

Fig. 16. Diagnostic plots for yellowfin delta lognormal models in regions 2s and 2n (regY2_R2 and regY2_R7) with vessel effects.

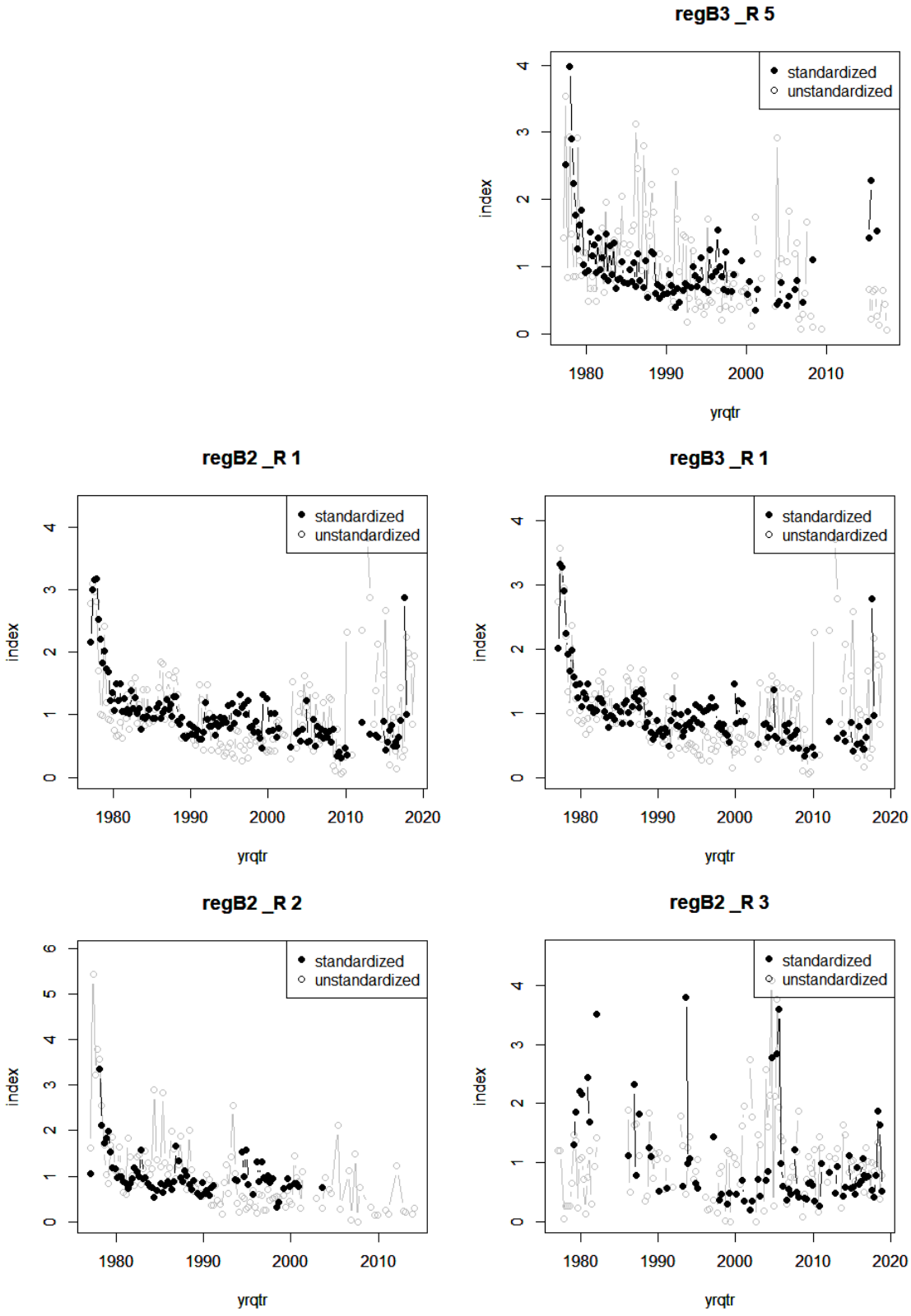

Fig. 17. Comparison plot of unstandardized and standardized indices for bigeye in region 1 (western tropical, regB2_R1), region 1S (south-western tropical, regB3_R1) and region 1N (north-western tropical, regB3_R5), region 2 (eastern tropical, regB2_R2) and region 3 (western temperate, regB2_R3).

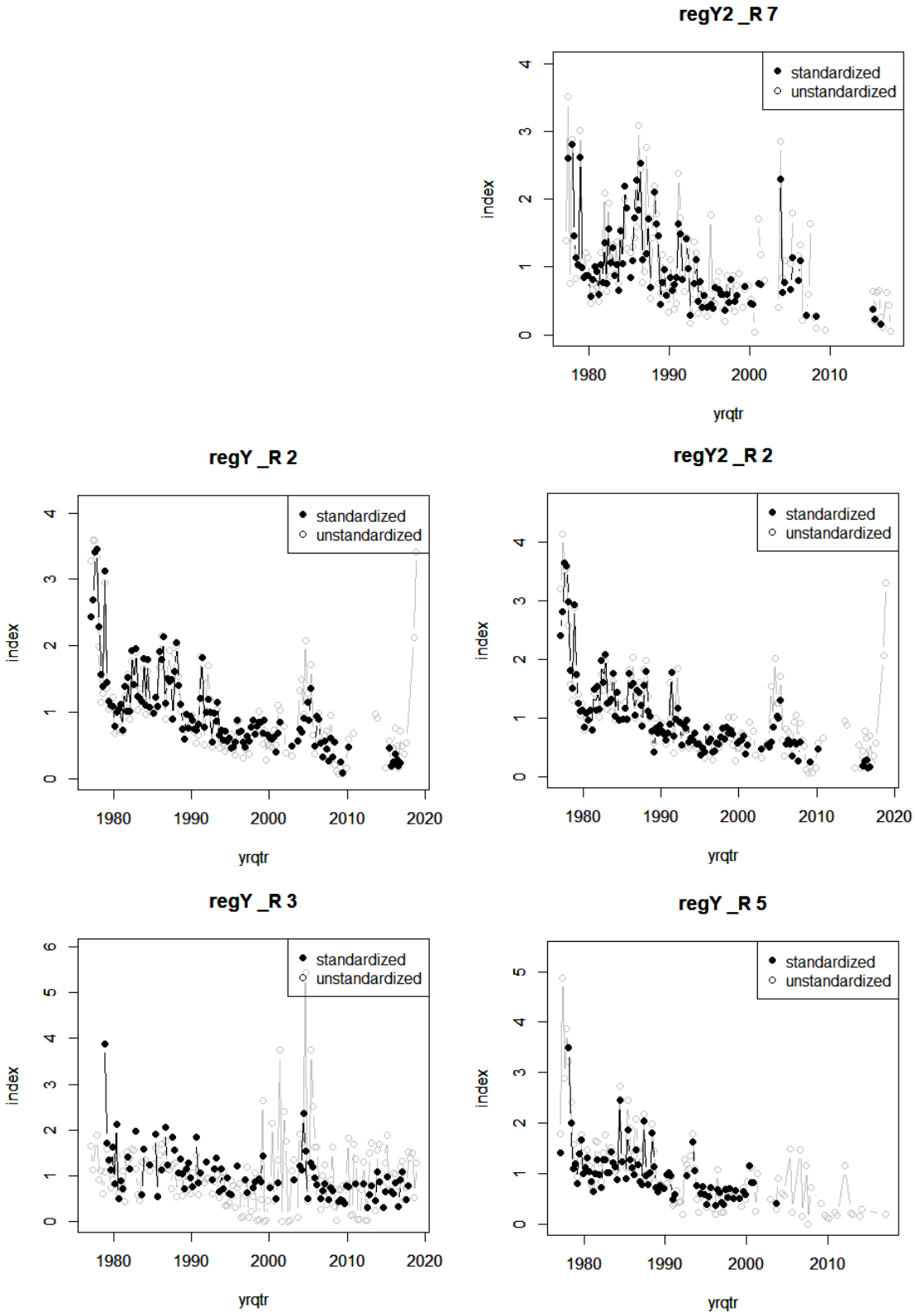

Fig. 18. Comparison plot of unstandardized and standardized indices for yellowfin in region 2 (western tropical, regY_R2), region 2S (south-western tropical, regY2_R2) and region 2N (north-western tropical, regY2_R7), region 3 (western temperate, regY_R3) and region 5 (eastern tropical, regY_R5).