SCIENTIFIC COMMITTEE
SIXTH REGULAR SESSION

CPUE STANDARDISATION FOR BIGEYE AND YELLOWFIN TUNA IN THE WESTERN AND CENTRAL PACIFIC OCEAN

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Executive summary

Indices of catch per unit effort are presented for bigeye and yellowfin tuna in the WCPO from 1952 to 2009, based on analyses of aggregated Japanese distant water longline data. One change was made to the methods for estimating indices of abundance for the bigeye and yellowfin stock assessments, with removal of the targeting indicator based on CPUE of other species. This change had little effect on the CPUE trends. An alternative CPUE trend for a subset of region 3 was estimated based on the area south of 10N. The trend for this sub-regional model was more optimistic in recent years. The full region 3 series may be biased by significant albacore-targeted effort in the north since 1995, so an index based on the southern region may be more reliable. Both the bigeye and yellowfin indices may be affected by increasing targeting of bigeye tuna in recent years.

1. Introduction

Indices of standardized catch per unit effort (CPUE) are a critical input into stock assessments carried out using integrated analysis methods (Fournier and Archibald 1982; Maunder 2003), such as Multifan-CL (Fournier *et al.* 1998). Indices for previous assessments have been prepared using generalized linear modelling and habitat-based standardization of data from the Japanese longline fleet (Langley 2003; Bigelow *et al.* 2004; Langley *et al.* 2005; Hoyle 2009). Indices are required for the 2010 bigeye tuna (*Thunnus obesus*) stock assessment (Harley *et al.* 2010). I describe the methods used to prepare these indices, and investigate changes to the analysis methods previously used, following recommendations from the 2010 pre-assessment workshop (Harley and Hoyle 2010), and information obtained from analyses of Japanese operational data (Hoyle *et al.* 2010).

The Japanese longline fleet has the longest history of widespread fishing of any fleet operating in the Pacific Ocean (1952-present). The catch and effort series (Figure 1 to Figure 3) represent the principal indices of relative abundance for that part of the biomass that is exploited by longline fisheries. These data are collected by the Japan Fisheries Agency and reported in an aggregated state, as described below. During the history of the fishery there have been systematic changes in the operation of the Japanese longline fleet that are likely to have influenced the catchability of the two species. These include changes in the geographic area fished (Figure 4); changed configuration of the longline gear, most notably increases in the number of hooks between floats (HBF); and changes in the principal target species. In recent years Japanese fishing effort has declined considerably, as has the area fished.

To account for such temporal changes in species-specific catchability of the longline fishery, the data have been standardized using a variety of approaches; most recently using generalised linear modelling techniques (McCullagh and Nelder 1989; Langley 2003; Langley *et al.* 2005; Hoyle 2009). In each case an identity link function and lognormal distribution have been assumed. The resulting region-specific standardised effort series are then integrated into the Multifan-CL (MFCL) assessments of yellowfin and bigeye in the WCPO.

Changes in fishing strategy can cause large changes in catch rates. However, the aggregated dataset holds information only on grid square, month, HBF, catch of the main tuna species, and number of hooks. Aggregated data provide limited opportunities to either observe or compensate for changes in fishing strategy (Hoyle *et al.* 2010). Various techniques have been used to adjust for fishing strategy changes. In 2009 a new approach was used, based on the catch rate per stratum of other species, offset by the relative abundance of that species. As recommended by the 2010 pre-assessment workshop, this paper compares the 2009 approach with a model that does not include catch of other species.

Analyses of operational data suggest that fishing practices in the north of region 3 may have changed since 1995, with increasing fishing effort targeted at albacore (Hoyle *et al.* 2010). Such changes are likely to significantly affect indices based on operational data. This paper therefore includes region 3 abundance indices that exclude the area north of 10°N.

In summary, this report documents the analyses undertaken to provide indices for the 2010 stock assessments, including modifications made to the GLM approach. It examines the methods currently used, makes changes in order to improve them, and suggests areas in which further improvements might be made.

2. Methods

The essentials of the method were as summarised in Langley et al (2005). Catch and effort data for the Japanese longline fleet for the period 1952 to 2009 are available aggregated by year, month, and spatial cell. Prior to 1966, the data are available at a five degree spatial resolution, i.e., aggregated by spatial cells of dimensions five degrees of latitude and longitude. From 1966, data are available at one degree spatial resolution. For years 1975 onwards, data are also stratified by the gear configuration of the longline (number of hooks between floats, HBF). In this analysis I assumed that all longline sets before 1975 had similar gear configuration to that deployed during the early 1970s, i.e., shallow sets deploying five HBF. Catch was recorded as the number of fish caught and effort as the number of hooks set.

Analyses were performed separately for each species and MFCL region, with an additional run for a subset of region 3. The WCPO stock assessment models for bigeye and yellowfin are currently stratified into six regions (1–6). The catch (bigeye and yellowfin catch in number) and effort (in hundreds of hooks) data were aggregated by year, quarter, five degree latitude and longitude cell, and HBF category. Spatial cells with few records (five or less) were excluded from the data set.

GLM indices were calculated by quarter for 1952–2009. The dependent variable in the GLMs was the natural logarithm of the catch (in numbers). Records with zero catch of the species of interest were excluded, but these were few given the high level of aggregation. The GLMs all had an equivalent model structure, including the categorical variables year/quarter, latitude/longitude, and the HBF, and the number of hooks as a continuous variable.

For yellowfin, the natural logarithm of the catch (in numbers) per year-quarter (*t*), and stratum (*st*) defined by five degree latitude/longitude (LL) cell and HBF was predicted as follows.

$$\mathrm{log}(\mathrm{yft}_{\mathrm{t,st}}) = \mathrm{c} + \alpha_{\mathrm{t}} + \beta_{\mathrm{LL}} + \mathrm{f}(\mathrm{HBF}_{\mathrm{t,st}}) + \mathrm{g}\left(\mathrm{log}(\mathrm{hooks}_{\mathrm{t,st}})\right) + \epsilon_{\mathrm{t,st}}$$

The function $\mathrm{f}(\mathrm{HBF}_{\mathrm{t,st}})$ estimated the parameters γ_{HBF} of the ordered HBF values by fitting a third-order polynomial. Similarly $\mathrm{g}\left(\mathrm{log}(\mathrm{hooks}_{\mathrm{t,st}})\right)$ fitted a cubic spline with 10 parameters to $\mathrm{log}(\mathrm{hooks}_{\mathrm{t,st}})$. Error $\epsilon_{t,st}$ was assumed to be normally distributed. The equivalent GLM was applied to predict region-specific bigeye catches $bet_{t,st}$. The CPUE index was the exponentiated year/quarter coefficients (a) from the region-specific GLM. The relationships between predicted catch and the dependent variables included in the GLM were examined for each model. Regional scaling factors were estimated and applied using approaches described previously for yellowfin (Hoyle and Langley 2007) and bigeye (Langley *et al.* 2005).

The model used in 2009 was

$$\mathrm{log}(\mathrm{yft}_{\mathrm{t,st}}) = \mathrm{c} + \alpha_{\mathrm{t}} + \beta_{\mathrm{LL}} + \mathrm{f}(\mathrm{HBF}_{\mathrm{t,st}}) + \mathrm{g}\left(\mathrm{log}(\mathrm{hooks}_{\mathrm{t,st}})\right) + \mathrm{h}(\mathrm{tg}_{\mathrm{t,st}}) + \epsilon_{\mathrm{t,st}}$$

which had the additional component $\mathrm{h}(\mathrm{tg}_{\mathrm{t,st}})$, which fitted a third-order polynomial to the target indicator variable $tg_{t,st}$.

The target indicator used the CPUE offset method, where the target species indicator based on the CPUE of the other species for the other species abundance at time *t*. The catch rate of the other species was offset by its abundance as estimated from the most recent stock assessment: $\frac{yft_{t,st}}{hooks_{t,st}} \cdot \frac{1}{Nyft_t}$, where $Nyft_t$ is the predicted number of yellowfin available for exploitation in the relevant regional longline fishery at time t.

Results were compared for the two approaches above.

3. Results

In comparison with the approaches used for the previous assessments, the targeting indicator based on the CPUE of other species with an offset for abundance (the 2009 approach) fitted the data better than the indicator using CPUE alone (the 2010 approach) (see Table 1 and Table 2).

Table 1: Akaike Information Criteria (AIC) by region for two models of bigeye CPUE. The model used in 2009 was changed by removing the targeting indicator. Smaller values represent a better fit.

Region	2009 approach with YFT offset	2010 approach
1	43781	44505
2	24213	24490
3	45036	45223
4	36694	37202
5	16302	16677
6	7115	7181
3 eq	24892	25037

Table 2: Akaike Information Criteria (AIC) by region for two models of yellowfin CPUE. The model used in 2009 was changed by removing the targeting indicator. Smaller values represent a better fit.

Region	2009 approach with YFT offset	2010 approach
1	43022	43733
2	23274	23480
3	50900	51177
4	47319	47635
5	16599	17067
6	6971	7035
3 eq	30388	30576

For bigeye, the switch away from using other species' CPUE as a targeting indicator produced indices that in subtropical regions 1, 2, 5, and 6 declined very slightly less at the start of the time series, and very slightly more at the end of the time series. There was minimal effect in regions 3 and 4. Surprisingly, the trends in regions 3 and 4 were quite close or even declined less than nominal CPUE (Figure 7 and Figure 8).

Annual indices are also presented (Figure 9).

Residuals from the 2010 GLM indicated positive kurtosis (i.e., distributions with a higher peak and longer tails than a normal distribution with the same mean) (Figure

10), and slight negative skewness (Figure 11). The negative residuals were very few in number and appear unlikely to bias the results of the model. The residuals generally show quite a good normal distribution for a GLM from fisheries data.

The bigeye targeting indicator based on catch rate of yellowfin, offset by yellowfin abundance estimates (Figure 12), showed a positive but nonlinear relationship with bigeye catch rates in all regions, particularly at low catch rates (Figure 13).

The bigeye regional scaling analysis estimated relative regional weights for regions 1 to 6 of 0.063, 0.16, 0.24, 0.45, 0.041, and 0.047 (Figure 14). The proportion of region 3 weight south of 10N was 0.63.

The combined bigeye indices, adjusted by regional scaling factors, are shown in Figure 15 and Figure 16. Individual values are reported in Table 3, with CV estimates in Table 4. The indices based on the whole of region 3 show considerably more decline at the end of the time series than the indices based on the equatorial region. The decline at the end of the time series is exaggerated by missing data for region 4 in the last quarter of 2009, region 5 since the third quarter of 2008, and region 6 since the end of 2007.

For yellowfin, using the 2010 approach instead of using the 2009 approach with a targeting indicator based on bigeye CPUE with an abundance offset had a minor effect on the indices, with more change outside tropical regions 3 and 4 (Figure 17 and Figure 18). There was slightly less seasonal variation in the new indices but little change in the trends. The trends in regions 3 and 4 declined considerably less than nominal CPUE (Figure 19 and Figure 20).

Annual indices of abundance are also presented (Figure 21).

Residuals from the 2010 GLM for yellowfin were very similar to those for bigeye, with positive kurtosis (Figure 22), and some negative skewness (Figure 23).

The yellowfin targeting indicator based on catch rate of bigeye, offset by bigeye abundance estimates (Figure 24), showed a positive but nonlinear relationship with yellowfin catch rates in all regions, particularly at low catch rates (Figure 25).

The yellowfin regional scaling analysis estimated relative regional weights for regions 1 to 6 of 0.029, 0.027, 0.47, 0.30, 0.13, and 0.044 (Figure 26). The proportion of region 3 weight south of 10N was 0.70.

The combined yellowfin indices, adjusted by regional scaling factors, are shown in Figure 27 and Figure 28. The indices based on the whole of region 3 are quite similar to those from the equatorial region alone. The decline at the end of the time series is exaggerated by missing data for region 4 in the last quarter of 2009, region 5 since the third quarter of 2008, and region 6 since the end of 2007.

4. Discussion

Indices estimated for the 2010 stock assessments show similar patterns to those estimated in 2009. One change was made to the methodology, but did not make a substantial difference to the results.

The targeting indicator based on yellowfin catch rate was removed, as recommended by the pre-assessment workshop (Harley and Hoyle 2010). This change resulted in a worse fit to the data, since catch rates of bigeye and yellowfin are correlated.

However, the change is likely to have marginally improved the quality of the abundance indices. A targeting indicator of this type may be problematic if its abundance is not independent of the abundance of the species of interest. In fact, parameter estimates indicate that the correlation between yellowfin and bigeye catch rates were positive across the majority of strata and catch rates in all regions. This was particularly true for strata with low catch rates. This suggests that the catch rate of the other species is not a good targeting indicator, but instead may indicate the quality of the habitat or strata characteristics for both species.

Results differed substantially between the whole of region 3 and the area of region 3 south of 10N. Analyses of operational data (Hoyle *et al.* 2010) suggest that indices from the northern areas may be affected by the introduction since 1995 of very significant albacore-targeted effort. This issue would particularly affect indices from aggregated data. The indices from the area south of 10N may be more relevant to the abundance trend of the bigeye stock in region 3.

Yellowfin catch rates declined steeply through the time series, while bigeye indices were quite stable. If vessels have increasingly targeted bigeye rather than yellowfin tuna, due to their higher value (Langley 2007; Hoyle *et al.* 2010), and that targeting has increased bigeye catch rates at the expense of yellowfin, then the bigeye abundance trend may be too optimistic and the yellowfin trend too pessimistic. This issue is recommended as a high priority for future research.

The data provided for these analyses are more recent (to the end of 2009 – within one year) than has been the case in the past (normally within 2 years). However, some data are missing at the end of the time for regions that are more distant from Japan, reflecting the lower effort in those areas and the length of the trips taken by vessels fishing there. In addition, declining coverage at the end of the time series may be affecting indices from the closer regions. These indices may only be usable up to early or mid-2009.

These indices are not adjusted for changes in catchability associated with changes in the fleet composition, as estimated in analyses of Japanese longline operational catch and effort data for bigeye tuna (Hoyle *et al.* 2010). Nor are they adjusted for changes in catchability that may have occurred within existing vessels.

5. References

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6. Tables

Table 3: CPUE indices for bigeye tuna

Year.qtr	1	2	3	4	5	6	3 sth of 10N
1952.125	2.37	1.89	1.90	2.56	-	-	1.57
1952.375	0.77	4.48	0.92	1.74	-	-	1.01
1952.625	1.77	3.85	0.93	2.05	3.34	-	0.93
1952.875	3.20	2.94	1.37	1.31	1.42	-	1.50
1953.125	1.68	3.52	1.17	1.44	0.91	0.43	1.56
1953.375	0.82	-	1.11	1.52	2.35	-	1.05
1953.625	0.99	4.16	1.72	1.52	1.61	-	1.71
1953.875	1.42	2.97	1.39	1.23	0.88	-	1.87
1954.125	1.66	2.06	1.19	1.25	1.37	0.57	1.15
1954.375	1.04	0.81	1.16	0.94	2.19	0.71	1.15
1954.625	0.71	3.36	1.22	1.28	1.75	1.34	1.20
1954.875	2.84	3.23	1.13	1.05	1.52	1.08	1.01
1955.125	1.93	2.38	1.32	1.37	1.45	0.43	1.19
1955.375	0.64	1.95	1.33	1.06	2.78	1.84	1.22
1955.625	1.45	2.80	1.23	0.77	1.67	1.19	1.21
1955.875	2.70	2.77	1.31	1.00	0.98	1.63	1.37
1956.125	3.05	3.29	1.32	1.00	0.75	0.49	1.19
1956.375	0.61	1.16	1.10	0.95	1.68	1.36	1.12
1956.625	1.38	2.08	1.20	1.68	2.05	1.84	1.28
1956.875	4.60	3.42	1.82	1.13	1.48	2.68	1.44
1957.125	3.33	4.25	1.51	1.21	1.25	1.21	1.19
1957.375	0.75	2.13	1.28	1.41	0.80	1.55	1.36
1957.625	2.46	1.98	1.67	1.27	2.27	1.27	1.74
1957.875	4.44	2.55	2.16	1.28	1.71	1.25	2.06
1958.125	3.54	3.29	1.83	1.71	0.99	1.07	1.60
1958.375	1.05	1.75	1.49	1.54	2.43	0.72	1.55
1958.625	1.62	3.03	1.71	1.27	1.36	1.02	1.63
1958.875	3.08	4.01	1.86	1.23	1.23	1.07	1.75
1959.125	2.69	2.95	1.77	1.17	0.93	0.90	1.69
1959.375	0.52	1.94	1.30	1.17	1.44	0.69	1.35
1959.625	1.12	2.22	1.23	1.04	1.96	1.10	1.23
1959.875	2.43	3.80	1.04	0.87	1.39	1.24	1.05
1960.125	2.83	2.53	1.12	1.05	0.98	0.95	1.01
1960.375	0.86	1.64	0.82	1.24	1.41	1.19	0.85
1960.625	1.28	1.03	0.82	1.07	1.70	0.80	0.80
1960.875	2.62	2.06	0.98	1.10	0.94	0.66	0.89
1961.125	2.13	2.07	1.00	1.10	0.96	0.53	0.87
1961.375	0.50	0.71	0.84	1.18	1.36	0.95	0.82
1961.625	0.54	1.09	0.90	0.96	0.63	0.61	0.84
1961.875	2.02	2.60	0.85	0.95	0.77	0.85	0.81
1962.125	1.52	1.02	0.89	1.05	1.47	0.64	0.72
1962.375	0.47	0.82	0.78	1.23	2.42	1.12	0.77
1962.625	1.09	0.66	0.79	1.03	1.45	1.19	0.85
1962.875	1.68	1.49	0.83	1.11	1.03	1.03	0.80
1963.125	2.29	1.58	0.89	1.21	1.31	0.71	0.87
1963.375	0.73	0.85	0.71	1.03	2.26	1.29	0.71
1963.625	1.10	0.71	0.87	0.94	1.35	1.14	0.89
1963.875	1.89	1.25	1.11	0.99	1.05	1.02	1.08
1964.125	2.05	1.45	0.91	1.17	1.18	1.48	0.80
1964.375	0.61	0.29	0.75	0.92	1.55	0.75	0.60
1964.625	0.55	0.65	0.74	0.88	1.36	1.12	0.66
1964.875	1.99	1.31	0.79	0.94	1.03	1.22	0.66
1965.125	1.68	1.69	0.84	0.94	1.79	1.10	0.86
1965.375	0.56	0.45	0.79	1.00	2.04	0.87	0.85
1965.625	0.51	0.54	0.92	0.92	1.33	0.72	0.95

1965.875	1.32	1.50	0.84	1.01	1.01	1.20	0.78
1966.125	1.43	2.28	0.98	1.26	1.10	0.72	0.91
1966.375	0.59	0.21	0.69	1.16	1.61	0.98	0.78
1966.625	1.06	1.70	0.71	0.90	0.91	0.77	0.67
1966.875	1.85	1.47	0.82	1.04	0.92	1.19	0.81
1967.125	1.86	1.61	0.75	1.16	1.22	1.18	0.68
1967.375	0.68	0.53	0.65	1.00	1.61	1.31	0.60
1967.625	0.62	0.83	0.74	0.89	1.45	1.00	0.73
1967.875	1.50	1.79	0.87	0.91	1.09	1.42	0.82
1968.125	1.33	1.42	0.78	1.04	1.26	0.96	0.74
1968.375	0.62	0.22	0.58	0.90	2.24	0.98	0.65
1968.625	0.65	0.72	0.70	0.81	1.04	0.78	0.85
1968.875	1.75	1.13	0.97	0.99	0.83	1.04	0.83
1969.125	1.39	2.48	1.12	1.09	1.77	1.15	1.05
1969.375	0.51	0.20	0.76	1.11	1.51	0.78	0.88
1969.625	0.70	1.18	0.77	0.98	1.28	1.00	0.89
1969.875	1.95	1.29	0.67	1.06	1.02	0.79	0.63
1970.125	1.47	1.76	0.61	0.85	1.67	1.64	0.65
1970.375	0.54	0.30	0.59	0.63	2.04	1.05	0.79
1970.625	0.74	0.35	0.46	0.60	1.13	0.75	0.60
1970.875	1.33	1.39	0.58	0.78	1.00	1.56	0.51
1971.125	1.15	1.11	0.58	0.76	1.02	1.33	0.56
1971.375	0.35	0.22	0.81	0.88	1.32	0.83	0.92
1971.625	0.41	0.86	0.65	0.73	0.96	0.87	0.73
1971.875	2.31	1.61	0.78	0.84	0.63	1.55	0.75
1972.125	1.64	1.39	1.04	0.93	1.18	0.93	1.10
1972.375	0.49	0.72	0.96	0.90	2.11	0.83	1.13
1972.625	0.59	0.89	0.85	0.90	1.11	0.83	0.93
1972.875	1.34	1.75	0.96	0.92	0.72	0.85	1.18
1973.125	1.16	1.22	1.11	1.13	1.99	0.77	0.88
1973.375	0.32	0.77	0.96	0.89	2.22	0.90	0.83
1973.625	0.42	0.59	0.81	0.81	1.44	1.43	0.71
1973.875	1.68	1.04	0.77	0.72	0.92	0.80	0.64
1974.125	1.29	0.88	0.77	0.77	1.12	1.38	0.67
1974.375	0.37	0.34	0.77	0.90	1.25	0.39	0.75
1974.625	0.68	0.59	0.83	0.79	0.78	0.70	0.81
1974.875	1.33	0.64	0.90	0.87	0.53	3.89	0.89
1975.125	1.07	0.49	1.20	1.00	0.67	1.68	1.08
1975.375	0.38	0.24	0.97	0.96	1.48	0.66	0.99
1975.625	0.61	0.27	0.87	0.96	0.53	0.33	0.92
1975.875	1.28	1.28	0.90	1.13	0.48	0.44	1.00
1976.125	1.02	0.99	0.91	1.04	0.70	1.61	0.87
1976.375	0.39	1.11	1.01	1.09	0.90	0.43	1.01
1976.625	0.61	0.56	0.90	0.83	1.28	0.74	0.90
1976.875	1.43	1.19	1.11	0.83	1.10	-	1.19
1977.125	1.87	1.01	1.34	1.16	0.74	1.10	1.21
1977.375	0.44	0.46	1.48	1.26	1.43	0.35	1.37
1977.625	0.54	1.14	1.32	0.97	0.54	0.04	1.20
1977.875	1.50	1.81	1.40	1.55	0.46	1.41	1.33
1978.125	1.29	1.23	1.10	1.31	0.72	0.73	1.07
1978.375	0.49	0.16	0.81	1.10	1.92	3.26	0.72
1978.625	0.43	0.69	0.75	0.87	1.20	1.93	0.74
1978.875	1.22	1.02	0.89	1.17	0.75	2.43	0.86
1979.125	0.86	0.68	0.90	1.07	1.08	-	0.83
1979.375	0.36	0.25	0.97	1.01	2.11	0.71	0.97
1979.625	0.41	0.66	0.98	1.02	1.32	1.99	1.07
1979.875	1.16	0.90	0.97	1.34	1.01	-	0.94
1980.125	1.00	0.63	1.06	1.18	0.99	1.80	1.00
1980.375	0.40	0.28	0.85	1.07	1.97	0.64	0.82
1980.625	0.73	0.83	0.76	0.75	0.90	1.84	0.71
1980.875	0.96	0.46	0.74	0.87	1.04	2.71	0.69

1981.125	0.71	0.38	0.73	0.97	0.80	0.87	0.68
1981.375	0.26	0.18	0.61	0.94	0.97	0.54	0.61
1981.625	0.91	0.63	0.46	0.64	0.59	1.66	0.47
1981.875	1.20	0.76	0.56	0.98	0.55	1.95	0.65
1982.125	0.84	0.71	0.65	0.96	0.58	1.02	0.66
1982.375	0.39	0.36	0.66	1.03	0.77	0.91	0.61
1982.625	0.61	0.99	0.67	1.03	0.48	0.95	0.64
1982.875	1.00	0.81	0.80	1.45	0.36	0.73	0.88
1983.125	0.72	0.69	0.56	1.10	0.55	1.30	0.53
1983.375	0.25	0.38	0.63	1.08	0.92	0.62	0.56
1983.625	0.54	0.59	0.60	0.84	0.69	1.95	0.66
1983.875	0.96	0.84	0.73	0.86	0.58	7.30	0.84
1984.125	0.82	0.65	0.88	1.07	0.74	0.80	0.79
1984.375	0.42	0.24	0.86	0.86	0.92	0.90	0.70
1984.625	0.77	0.66	0.77	0.89	0.59	1.67	0.83
1984.875	0.97	0.75	0.89	0.89	0.48	3.38	0.91
1985.125	0.69	0.45	0.90	1.00	0.61	1.68	0.86
1985.375	0.25	0.15	0.91	0.87	1.26	2.50	0.86
1985.625	0.32	0.54	0.84	1.09	0.82	1.89	0.85
1985.875	0.98	0.72	0.85	1.25	0.85	-	0.87
1986.125	0.86	0.51	0.98	0.90	0.68	0.67	0.86
1986.375	0.31	0.24	0.82	0.91	1.42	0.84	0.79
1986.625	0.55	0.57	0.96	0.85	0.85	1.84	0.87
1986.875	1.05	0.65	1.44	0.88	0.81	1.75	1.41
1987.125	1.02	0.44	1.37	1.27	0.78	0.37	1.30
1987.375	0.41	0.28	1.36	1.08	1.33	0.31	1.26
1987.625	0.61	0.53	1.19	0.96	0.77	1.45	1.25
1987.875	1.51	0.85	1.14	1.00	0.55	0.81	1.15
1988.125	0.84	0.61	1.00	0.93	0.71	-	0.98
1988.375	0.44	0.40	0.87	0.78	0.97	0.34	0.77
1988.625	0.52	0.61	0.77	0.59	0.77	0.81	0.73
1988.875	1.01	0.58	0.88	0.91	0.60	1.29	0.81
1989.125	0.75	0.50	0.99	0.79	0.66	0.44	0.95
1989.375	0.34	0.34	1.14	0.81	0.98	0.37	1.12
1989.625	0.45	0.44	1.44	0.74	0.66	1.11	1.39
1989.875	1.27	0.74	1.52	1.08	0.34	0.45	1.51
1990.125	0.98	0.61	1.89	0.95	0.63	0.71	1.73
1990.375	0.41	0.25	1.63	0.98	1.10	1.00	1.51
1990.625	0.46	0.53	1.53	0.89	0.75	1.02	1.41
1990.875	1.29	0.86	1.38	0.92	0.52	0.38	1.21
1991.125	0.90	0.65	1.39	0.90	0.56	0.98	1.20
1991.375	0.52	0.33	1.30	0.81	0.62	0.27	1.07
1991.625	0.66	0.68	1.04	0.77	0.79	0.43	0.99
1991.875	1.09	0.74	1.06	0.86	0.34	0.09	0.97
1992.125	1.03	0.68	1.44	1.00	0.30	0.18	1.30
1992.375	0.41	0.46	1.26	1.03	0.70	0.22	1.16
1992.625	0.47	0.43	1.09	0.83	0.57	0.55	1.05
1992.875	1.37	1.21	0.97	0.77	0.83	0.42	0.95
1993.125	1.44	0.88	1.10	0.79	0.41	0.12	0.99
1993.375	0.45	0.54	1.06	0.88	0.60	0.12	0.99
1993.625	0.73	0.55	0.81	0.86	0.61	0.22	0.81
1993.875	1.08	0.67	0.88	0.76	0.53	-	0.86
1994.125	0.86	0.45	0.98	0.81	0.48	-	0.86
1994.375	0.42	0.34	1.10	0.91	0.78	0.12	1.07
1994.625	0.41	0.65	1.00	0.92	0.64	-	0.93
1994.875	0.80	0.46	1.18	0.97	0.28	-	1.09
1995.125	0.83	0.53	1.13	1.05	0.43	-	0.98
1995.375	0.34	0.28	0.94	0.68	0.53	0.24	0.86
1995.625	0.58	0.53	0.78	0.52	0.62	0.11	0.77
1995.875	0.84	0.25	0.78	0.70	0.50	-	0.81
1996.125	0.67	0.23	1.00	0.78	0.44	0.60	0.96

1996.375	0.27	0.28	0.94	0.89	0.66	0.21	1.03
1996.625	0.44	0.65	0.85	0.72	1.24	0.75	0.85
1996.875	1.21	0.71	0.90	0.79	0.35	-	0.86
1997.125	1.15	0.51	1.12	0.97	0.47	0.16	1.11
1997.375	0.43	0.50	0.81	1.12	0.58	0.30	1.01
1997.625	0.64	0.93	0.90	1.29	0.97	0.13	1.09
1997.875	1.16	0.71	1.51	1.69	0.41	-	1.52
1998.125	0.78	0.39	1.15	2.08	0.72	0.24	1.36
1998.375	0.30	0.49	0.90	1.78	0.64	1.37	0.93
1998.625	0.54	0.85	0.88	1.25	0.92	0.55	1.00
1998.875	0.88	0.59	0.93	0.95	0.90	1.57	0.96
1999.125	0.84	0.40	1.12	0.90	0.90	0.60	1.19
1999.375	0.43	0.29	0.88	0.78	0.92	0.98	1.09
1999.625	0.30	0.70	0.90	0.66	1.06	0.78	1.05
1999.875	0.86	0.64	0.98	0.72	0.46	0.62	0.97
2000.125	0.74	0.38	0.98	0.73	0.61	0.41	1.10
2000.375	0.21	0.20	0.82	0.96	0.61	0.84	0.90
2000.625	0.28	0.40	0.91	0.72	1.14	1.29	0.94
2000.875	0.70	0.43	0.89	0.56	1.52	0.85	0.89
2001.125	0.60	0.31	0.81	0.74	1.06	-	1.08
2001.375	0.25	0.03	0.77	0.84	0.41	0.36	1.13
2001.625	0.31	0.29	1.00	0.78	1.39	1.47	1.07
2001.875	1.05	0.46	1.25	0.72	0.55	0.19	1.06
2002.125	0.78	0.36	1.06	0.96	0.44	0.40	1.07
2002.375	0.51	0.19	1.09	1.17	0.54	1.08	1.25
2002.625	0.57	0.65	0.95	0.95	0.64	0.58	1.13
2002.875	1.18	0.80	1.14	1.04	0.30	0.11	1.03
2003.125	0.68	0.81	1.16	1.03	0.55	1.00	0.89
2003.375	1.01	0.08	1.25	0.68	0.53	0.50	1.05
2003.625	0.32	0.61	0.98	0.61	0.63	0.73	1.07
2003.875	0.73	0.64	1.24	0.91	0.54	0.11	1.28
2004.125	0.44	0.27	1.28	1.03	0.52	0.27	1.36
2004.375	0.26	0.03	1.40	1.29	0.57	0.67	1.48
2004.625	0.29	0.55	1.01	1.26	1.03	1.88	1.25
2004.875	1.00	0.86	1.09	0.88	0.54	0.20	1.04
2005.125	0.68	0.75	0.91	0.88	0.35	0.23	0.91
2005.375	0.40	0.09	0.76	0.76	0.38	0.85	0.76
2005.625	0.45	0.65	0.80	0.71	0.79	1.20	0.78
2005.875	0.91	0.60	0.91	0.89	0.14	1.70	0.94
2006.125	0.55	0.28	1.28	0.75	0.25	-	1.10
2006.375	0.47	0.10	1.04	0.74	0.37	0.74	1.18
2006.625	0.57	0.34	1.03	0.70	0.44	0.62	0.99
2006.875	1.06	0.72	0.96	0.91	0.53	0.24	0.75
2007.125	0.68	0.35	1.01	1.08	0.22	0.13	0.84
2007.375	0.30	0.04	0.61	0.77	0.34	-	0.69
2007.625	0.32	0.43	0.78	0.91	0.45	1.45	0.75
2007.875	0.70	0.48	0.73	0.79	0.51	1.36	0.63
2008.125	0.52	0.45	1.27	0.81	0.37	-	1.39
2008.375	0.24	0.06	0.89	0.51	0.79	-	1.03
2008.625	0.35	0.59	0.51	0.83	0.56	-	0.77
2008.875	0.78	0.47	1.10	0.98	-	-	1.47
2009.125	0.46	0.24	0.69	0.71	-	-	1.59
2009.375	0.37	0.13	0.42	0.62	-	-	0.96
2009.625	0.44	0.43	0.65	1.04	-	-	1.17
2009.875	0.98	0.40	0.61	-	-	-	1.40

Table 4: CV estimates for bigeye tuna CPUE indices

Year.qtr	1	2	3	4	5	6	3 sth of 10N
1952.13	0.47	0.72	0.19	0.40	-	-	0.16
1952.38	0.25	0.67	0.17	0.25	-	-	0.17
1952.63	0.33	0.54	0.21	0.27	0.67	-	0.20
1952.88	0.25	0.44	0.20	0.25	0.81	-	0.20
1953.13	0.25	0.42	0.18	0.29	0.73	0.53	0.19
1953.38	0.24	-	0.19	0.26	0.77	-	0.18
1953.63	0.29	0.67	0.18	0.26	0.75	-	0.18
1953.88	0.25	0.42	0.18	0.25	0.72	-	0.18
1954.13	0.25	0.42	0.17	0.26	0.67	0.58	0.18
1954.38	0.25	0.50	0.17	0.24	0.69	1.01	0.17
1954.63	0.29	0.45	0.19	0.25	0.67	0.57	0.18
1954.88	0.24	0.41	0.18	0.26	0.67	0.52	0.18
1955.13	0.23	0.40	0.17	0.25	0.67	0.51	0.17
1955.38	0.24	0.42	0.17	0.24	0.82	0.53	0.17
1955.63	0.29	0.40	0.18	0.24	0.67	0.49	0.18
1955.88	0.24	0.39	0.18	0.23	0.69	0.49	0.18
1956.13	0.23	0.39	0.17	0.24	0.69	0.53	0.17
1956.38	0.24	0.43	0.17	0.24	0.71	0.53	0.18
1956.63	0.31	0.41	0.18	0.24	0.69	0.49	0.18
1956.88	0.24	0.39	0.17	0.24	0.67	0.49	0.18
1957.13	0.23	0.40	0.17	0.24	0.73	0.56	0.18
1957.38	0.24	0.45	0.17	0.24	0.89	0.54	0.17
1957.63	0.28	0.40	0.19	0.24	0.67	0.50	0.18
1957.88	0.24	0.40	0.18	0.23	0.67	0.49	0.18
1958.13	0.24	0.40	0.17	0.24	0.70	0.54	0.17
1958.38	0.25	0.42	0.17	0.24	0.89	0.57	0.18
1958.63	0.27	0.40	0.19	0.24	0.66	0.48	0.19
1958.88	0.24	0.40	0.18	0.24	0.66	0.49	0.18
1959.13	0.24	0.40	0.17	0.24	0.69	0.54	0.18
1959.38	0.25	0.42	0.18	0.24	0.68	0.52	0.18
1959.63	0.27	0.40	0.19	0.24	0.67	0.49	0.18
1959.88	0.24	0.39	0.17	0.24	0.67	0.49	0.17
1960.13	0.24	0.39	0.17	0.24	0.69	0.55	0.18
1960.38	0.25	0.40	0.17	0.23	0.71	0.49	0.18
1960.63	0.27	0.40	0.18	0.24	0.67	0.49	0.18
1960.88	0.24	0.39	0.17	0.24	0.67	0.49	0.18
1961.13	0.24	0.40	0.17	0.23	0.77	0.52	0.17
1961.38	0.25	0.42	0.17	0.23	0.82	0.51	0.18
1961.63	0.27	0.41	0.18	0.24	0.66	0.49	0.18
1961.88	0.23	0.40	0.17	0.24	0.66	0.49	0.18
1962.13	0.24	0.39	0.17	0.23	0.67	0.52	0.17
1962.38	0.24	0.40	0.17	0.23	0.67	0.51	0.17
1962.63	0.28	0.40	0.17	0.24	0.66	0.49	0.17
1962.88	0.24	0.39	0.16	0.23	0.66	0.48	0.17
1963.13	0.24	0.39	0.17	0.23	0.68	0.51	0.17
1963.38	0.24	0.40	0.17	0.23	0.66	0.48	0.17
1963.63	0.29	0.39	0.18	0.23	0.66	0.47	0.18
1963.88	0.23	0.39	0.17	0.23	0.66	0.48	0.17
1964.13	0.24	0.39	0.17	0.23	0.66	0.50	0.17
1964.38	0.25	0.42	0.18	0.23	0.66	0.49	0.18
1964.63	0.25	0.40	0.17	0.23	0.66	0.48	0.17
1964.88	0.24	0.39	0.17	0.23	0.66	0.48	0.17
1965.13	0.23	0.39	0.17	0.23	0.67	0.51	0.17
1965.38	0.24	0.41	0.17	0.23	0.66	0.51	0.18
1965.63	0.24	0.41	0.17	0.23	0.66	0.48	0.17
1965.88	0.23	0.39	0.17	0.23	0.66	0.48	0.17
1966.13	0.19	0.38	0.15	0.22	0.65	0.49	0.15
1966.38	0.20	0.42	0.15	0.22	0.64	0.47	0.15

1966.63	0.21	0.38	0.15	0.22	0.64	0.47	0.15
1966.88	0.19	0.37	0.15	0.22	0.64	0.47	0.15
1967.13	0.23	0.40	0.17	0.23	0.66	0.50	0.17
1967.38	0.24	0.40	0.17	0.23	0.66	0.48	0.17
1967.63	0.24	0.39	0.17	0.23	0.66	0.48	0.17
1967.88	0.24	0.39	0.17	0.23	0.66	0.49	0.17
1968.13	0.23	0.39	0.17	0.23	0.67	0.50	0.17
1968.38	0.25	0.42	0.17	0.23	0.66	0.48	0.17
1968.63	0.25	0.40	0.17	0.24	0.66	0.49	0.17
1968.88	0.23	0.39	0.17	0.23	0.66	0.50	0.17
1969.13	0.23	0.39	0.17	0.23	0.66	0.51	0.17
1969.38	0.25	0.47	0.17	0.23	0.67	0.50	0.17
1969.63	0.24	0.40	0.17	0.23	0.67	0.50	0.18
1969.88	0.24	0.39	0.17	0.23	0.66	0.56	0.18
1970.13	0.23	0.39	0.17	0.23	0.67	0.51	0.18
1970.38	0.25	0.41	0.17	0.23	0.67	0.51	0.18
1970.63	0.24	0.40	0.17	0.23	0.66	0.50	0.17
1970.88	0.24	0.39	0.17	0.23	0.66	0.51	0.18
1971.13	0.23	0.39	0.17	0.23	0.66	0.51	0.17
1971.38	0.25	0.45	0.17	0.23	0.67	0.51	0.18
1971.63	0.25	0.40	0.17	0.23	0.67	0.51	0.17
1971.88	0.24	0.39	0.17	0.24	0.66	0.51	0.18
1972.13	0.24	0.40	0.17	0.24	0.66	0.52	0.19
1972.38	0.26	0.45	0.17	0.23	0.69	0.53	0.18
1972.63	0.29	0.42	0.17	0.23	0.66	0.50	0.17
1972.88	0.25	0.38	0.17	0.23	0.67	0.54	0.19
1973.13	0.24	0.39	0.17	0.23	0.67	0.55	0.18
1973.38	0.25	0.43	0.17	0.23	0.68	0.56	0.18
1973.63	0.26	0.41	0.18	0.23	0.66	0.64	0.18
1973.88	0.24	0.39	0.17	0.24	0.67	0.64	0.18
1974.13	0.24	0.39	0.17	0.24	0.66	0.57	0.17
1974.38	0.25	0.51	0.16	0.24	0.67	0.69	0.17
1974.63	0.26	0.41	0.17	0.23	0.66	0.57	0.18
1974.88	0.24	0.39	0.17	0.23	0.66	0.64	0.17
1975.13	0.19	0.38	0.14	0.22	0.66	0.54	0.14
1975.38	0.22	0.48	0.15	0.22	0.68	0.59	0.15
1975.63	0.22	0.43	0.15	0.22	0.66	0.64	0.14
1975.88	0.20	0.37	0.14	0.22	0.67	1.02	0.14
1976.13	0.19	0.36	0.14	0.22	0.65	0.52	0.14
1976.38	0.21	0.40	0.15	0.22	0.67	0.55	0.14
1976.63	0.20	0.38	0.14	0.22	0.66	0.61	0.14
1976.88	0.19	0.36	0.14	0.22	0.68	-	0.14
1977.13	0.19	0.36	0.14	0.22	0.68	0.56	0.14
1977.38	0.21	0.67	0.14	0.22	0.68	0.57	0.14
1977.63	0.20	0.37	0.15	0.22	0.73	1.01	0.14
1977.88	0.19	0.36	0.15	0.22	0.67	0.64	0.14
1978.13	0.19	0.37	0.14	0.22	0.66	0.54	0.14
1978.38	0.21	0.40	0.14	0.22	0.67	0.79	0.14
1978.63	0.21	0.37	0.14	0.22	0.67	1.02	0.14
1978.88	0.19	0.36	0.15	0.22	0.66	0.71	0.14
1979.13	0.19	0.36	0.14	0.22	0.66	-	0.14
1979.38	0.21	0.37	0.14	0.22	0.66	0.61	0.14
1979.63	0.20	0.37	0.15	0.22	0.65	0.52	0.14
1979.88	0.19	0.36	0.15	0.22	0.65	-	0.15
1980.13	0.19	0.37	0.14	0.22	0.66	0.56	0.14
1980.38	0.21	0.42	0.14	0.22	0.65	0.56	0.14
1980.63	0.21	0.39	0.15	0.22	0.65	0.50	0.14
1980.88	0.19	0.36	0.15	0.22	0.64	0.57	0.14
1981.13	0.19	0.36	0.14	0.22	0.64	0.52	0.14
1981.38	0.20	0.39	0.14	0.22	0.65	0.57	0.14
1981.63	0.20	0.38	0.15	0.22	0.64	0.51	0.14

1981.88	0.19	0.36	0.15	0.22	0.64	0.64	0.15
1982.13	0.19	0.36	0.15	0.22	0.64	0.52	0.15
1982.38	0.21	0.40	0.15	0.22	0.64	0.52	0.14
1982.63	0.20	0.38	0.15	0.22	0.65	0.50	0.14
1982.88	0.19	0.37	0.15	0.22	0.65	0.65	0.15
1983.13	0.19	0.37	0.15	0.22	0.65	0.52	0.15
1983.38	0.21	0.39	0.15	0.22	0.65	0.55	0.15
1983.63	0.20	0.39	0.15	0.22	0.65	0.51	0.15
1983.88	0.19	0.37	0.15	0.22	0.64	0.80	0.15
1984.13	0.19	0.37	0.15	0.22	0.65	0.55	0.14
1984.38	0.21	0.46	0.15	0.22	0.65	0.55	0.15
1984.63	0.20	0.39	0.15	0.22	0.65	0.50	0.15
1984.88	0.19	0.37	0.15	0.22	0.65	1.03	0.15
1985.13	0.19	0.37	0.15	0.22	0.65	0.59	0.14
1985.38	0.23	0.43	0.15	0.22	0.65	0.57	0.14
1985.63	0.20	0.38	0.15	0.22	0.65	0.53	0.14
1985.88	0.19	0.36	0.15	0.22	0.65	-	0.14
1986.13	0.19	0.36	0.15	0.22	0.65	0.51	0.15
1986.38	0.21	0.42	0.15	0.22	0.65	0.51	0.15
1986.63	0.20	0.38	0.15	0.22	0.65	0.52	0.15
1986.88	0.19	0.36	0.15	0.22	0.66	0.65	0.15
1987.13	0.19	0.37	0.15	0.22	0.65	0.52	0.15
1987.38	0.21	0.40	0.15	0.22	0.66	0.55	0.15
1987.63	0.20	0.38	0.15	0.22	0.65	0.50	0.15
1987.88	0.19	0.36	0.15	0.22	0.66	1.03	0.15
1988.13	0.19	0.37	0.15	0.22	0.65	-	0.15
1988.38	0.21	0.40	0.15	0.22	0.65	0.52	0.15
1988.63	0.21	0.38	0.15	0.22	0.65	0.51	0.15
1988.88	0.20	0.36	0.15	0.22	0.65	1.03	0.15
1989.13	0.19	0.37	0.15	0.22	0.66	0.79	0.14
1989.38	0.21	0.38	0.15	0.22	0.65	0.58	0.14
1989.63	0.21	0.38	0.15	0.22	0.65	0.53	0.14
1989.88	0.20	0.37	0.15	0.23	0.66	0.70	0.14
1990.13	0.19	0.37	0.15	0.22	0.65	0.65	0.14
1990.38	0.21	0.41	0.15	0.22	0.65	0.59	0.14
1990.63	0.21	0.40	0.15	0.22	0.64	0.50	0.14
1990.88	0.20	0.37	0.15	0.22	0.67	0.56	0.14
1991.13	0.19	0.37	0.15	0.22	0.66	0.55	0.14
1991.38	0.22	0.40	0.15	0.22	0.65	0.54	0.15
1991.63	0.20	0.38	0.15	0.22	0.65	0.52	0.14
1991.88	0.19	0.37	0.15	0.24	0.67	0.57	0.14
1992.13	0.20	0.37	0.15	0.22	0.66	1.02	0.15
1992.38	0.22	0.42	0.15	0.22	0.66	0.56	0.14
1992.63	0.21	0.41	0.15	0.23	0.64	0.51	0.14
1992.88	0.20	0.37	0.15	0.23	0.66	0.65	0.14
1993.13	0.19	0.37	0.15	0.22	0.65	1.01	0.15
1993.38	0.20	0.44	0.15	0.22	0.64	0.65	0.14
1993.63	0.20	0.41	0.15	0.22	0.64	0.59	0.14
1993.88	0.19	0.37	0.15	0.22	0.67	-	0.15
1994.13	0.19	0.37	0.15	0.22	0.65	-	0.14
1994.38	0.20	0.58	0.15	0.22	0.64	0.70	0.14
1994.63	0.20	0.38	0.15	0.22	0.64	-	0.15
1994.88	0.19	0.37	0.15	0.22	0.65	-	0.15
1995.13	0.20	0.37	0.15	0.22	0.64	-	0.14
1995.38	0.21	0.43	0.15	0.22	0.64	0.59	0.14
1995.63	0.20	0.39	0.15	0.22	0.65	0.62	0.14
1995.88	0.19	0.37	0.15	0.22	0.65	-	0.15
1996.13	0.19	0.37	0.15	0.22	0.65	0.79	0.15
1996.38	0.21	0.43	0.15	0.22	0.65	0.58	0.15
1996.63	0.20	0.38	0.15	0.22	0.65	0.55	0.15
1996.88	0.19	0.37	0.16	0.22	0.82	-	0.16

1997.13	0.20	0.37	0.16	0.22	0.66	0.70	0.15
1997.38	0.20	0.41	0.15	0.22	0.65	0.65	0.15
1997.63	0.20	0.39	0.15	0.22	0.65	0.79	0.15
1997.88	0.19	0.37	0.16	0.23	0.73	-	0.15
1998.13	0.20	0.38	0.15	0.22	0.66	0.58	0.15
1998.38	0.20	0.41	0.15	0.22	0.65	0.62	0.15
1998.63	0.20	0.39	0.15	0.22	0.65	0.49	0.15
1998.88	0.20	0.37	0.15	0.22	0.70	0.67	0.15
1999.13	0.20	0.38	0.15	0.22	0.67	0.60	0.15
1999.38	0.20	0.42	0.15	0.22	0.66	0.53	0.15
1999.63	0.21	0.37	0.15	0.22	0.65	0.49	0.15
1999.88	0.19	0.37	0.15	0.22	0.89	0.70	0.15
2000.13	0.20	0.38	0.15	0.22	0.67	0.79	0.15
2000.38	0.21	0.51	0.15	0.22	0.65	0.79	0.15
2000.63	0.21	0.39	0.15	0.22	0.66	0.57	0.15
2000.88	0.19	0.37	0.16	0.22	0.82	0.66	0.16
2001.13	0.20	0.38	0.15	0.22	0.73	-	0.15
2001.38	0.22	0.43	0.15	0.22	0.67	0.58	0.15
2001.63	0.21	0.38	0.15	0.22	0.66	0.52	0.15
2001.88	0.19	0.37	0.15	0.22	0.66	0.62	0.15
2002.13	0.20	0.37	0.15	0.22	0.66	0.62	0.15
2002.38	0.21	0.41	0.15	0.22	0.66	0.56	0.15
2002.63	0.21	0.38	0.16	0.22	0.65	0.52	0.16
2002.88	0.20	0.37	0.16	0.22	0.67	1.03	0.16
2003.13	0.20	0.38	0.15	0.22	0.66	0.71	0.16
2003.38	0.20	0.40	0.15	0.22	0.66	0.62	0.16
2003.63	0.22	0.37	0.15	0.22	0.65	0.52	0.15
2003.88	0.20	0.37	0.16	0.23	0.67	0.79	0.15
2004.13	0.20	0.37	0.16	0.22	0.67	0.62	0.15
2004.38	0.22	0.40	0.15	0.22	0.66	0.79	0.15
2004.63	0.23	0.39	0.16	0.22	0.65	0.54	0.15
2004.88	0.20	0.37	0.16	0.22	0.67	0.81	0.16
2005.13	0.20	0.38	0.15	0.22	0.67	0.58	0.15
2005.38	0.21	0.40	0.15	0.22	0.66	0.79	0.16
2005.63	0.23	0.38	0.15	0.22	0.65	0.55	0.15
2005.88	0.20	0.37	0.17	0.23	0.73	0.60	0.16
2006.13	0.21	0.37	0.16	0.22	0.69	-	0.16
2006.38	0.22	0.40	0.15	0.23	0.65	0.63	0.16
2006.63	0.22	0.38	0.16	0.23	0.65	0.52	0.16
2006.88	0.20	0.37	0.17	0.23	0.69	0.80	0.17
2007.13	0.20	0.38	0.15	0.22	0.67	0.81	0.16
2007.38	0.21	0.41	0.16	0.22	0.66	-	0.17
2007.63	0.22	0.37	0.17	0.23	0.66	0.57	0.17
2007.88	0.20	0.37	0.19	0.23	0.69	0.66	0.18
2008.13	0.20	0.38	0.17	0.23	0.75	-	0.19
2008.38	0.21	0.41	0.16	0.23	0.73	-	0.17
2008.63	0.22	0.41	0.17	0.30	0.75	-	0.18
2008.88	0.20	0.38	0.18	0.28	-	-	0.23
2009.13	0.21	0.54	0.17	0.23	-	-	0.19
2009.38	0.22	0.47	0.17	0.27	-	-	0.21
2009.63	0.23	0.40	0.17	0.64	-	-	0.19
2009.88	0.22	0.39	0.23	-	-	-	0.57

7. Figures

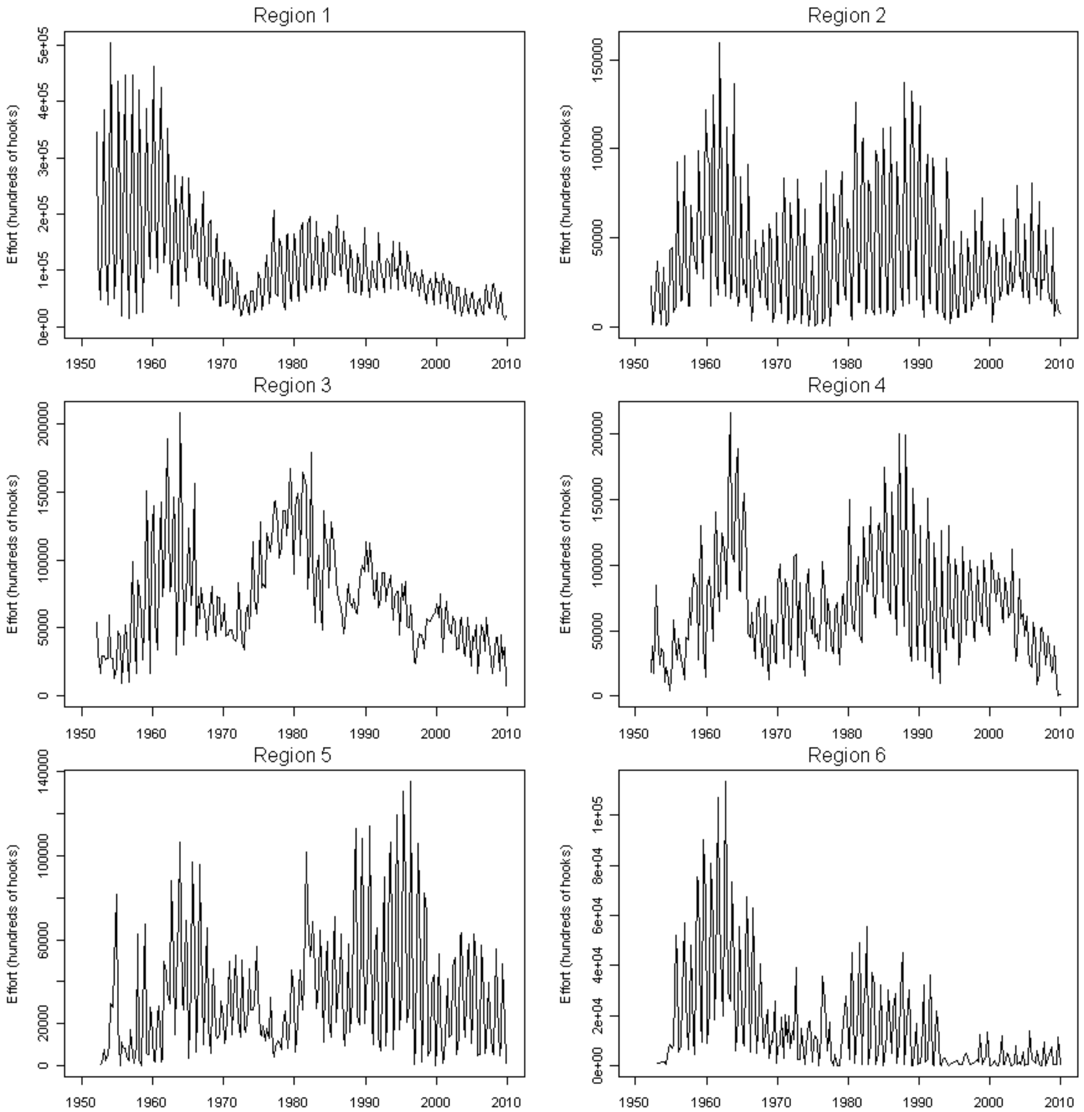

Figure 1: Effort by region and year-quarter by the Japanese distant-water longline fleet, as recorded in the aggregated dataset.

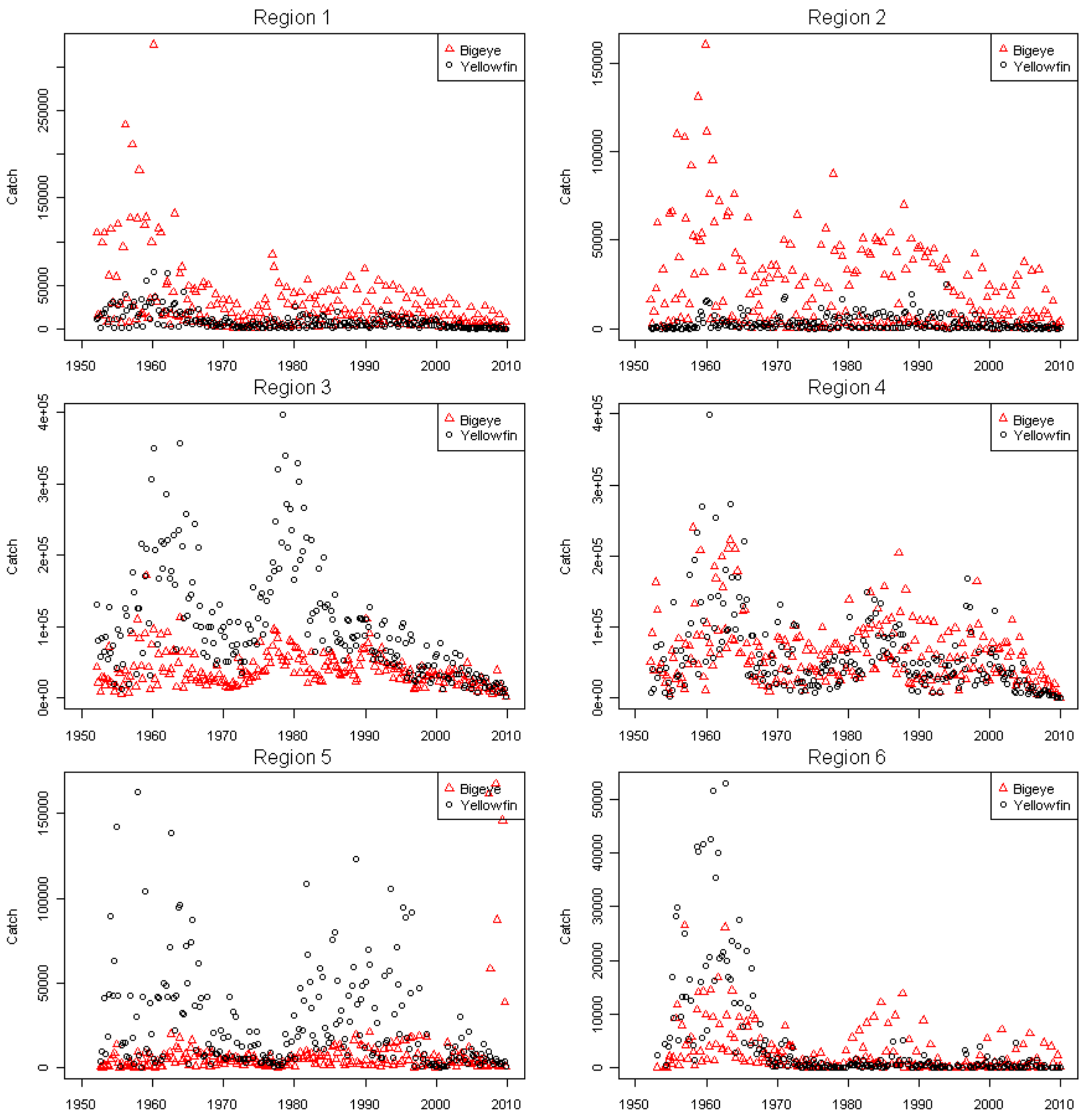

Figure 2: Catch of bigeye and yellowfin tuna by region and year-quarter, by the Japanese distant-water longline fleet, as recorded in the aggregated dataset.

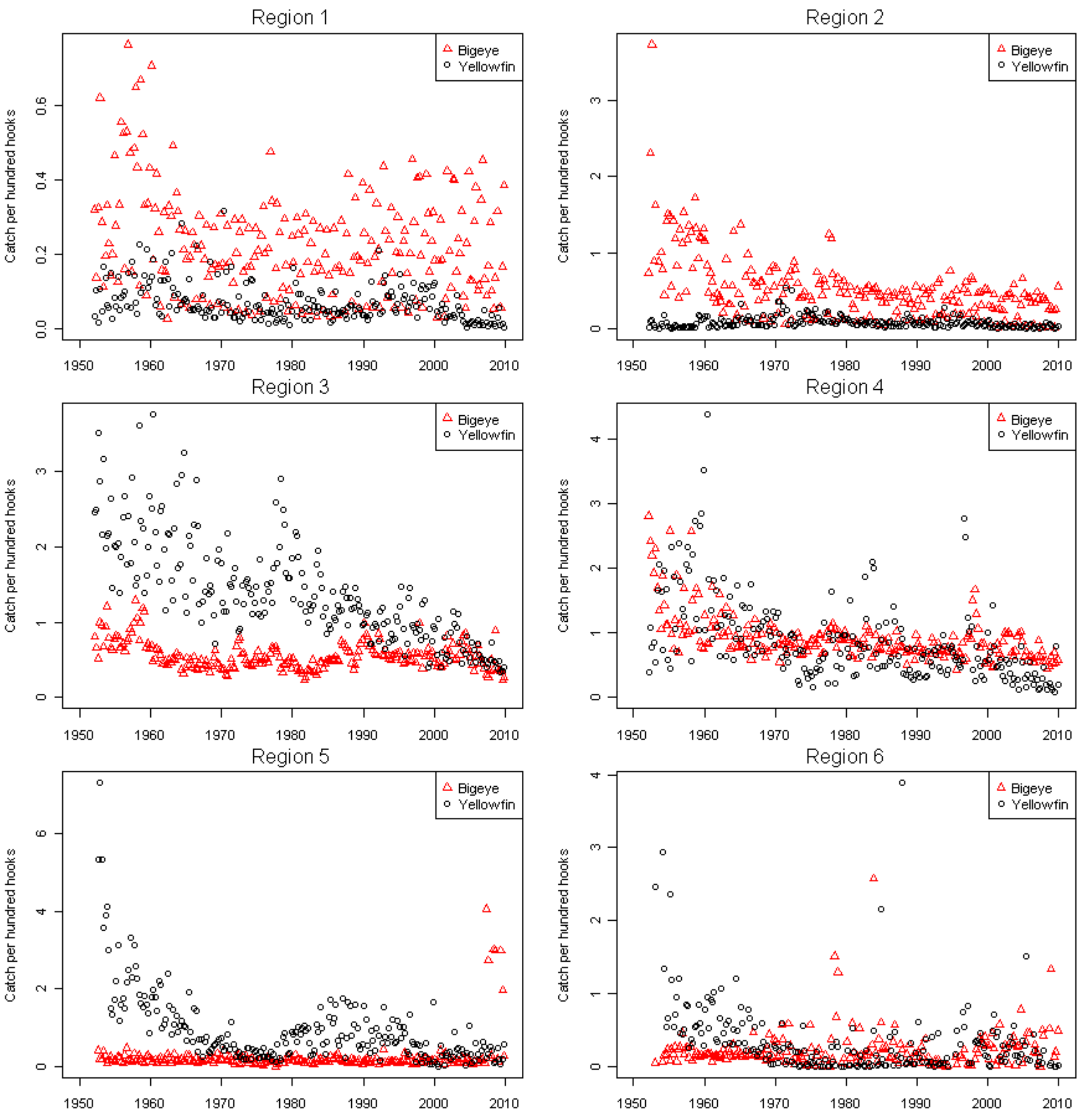

Figure 3: Nominal catch per unit of effort of bigeye and yellowfin tuna by region and year-quarter, by the Japanese distant-water longline fleet, as recorded in the aggregated dataset.

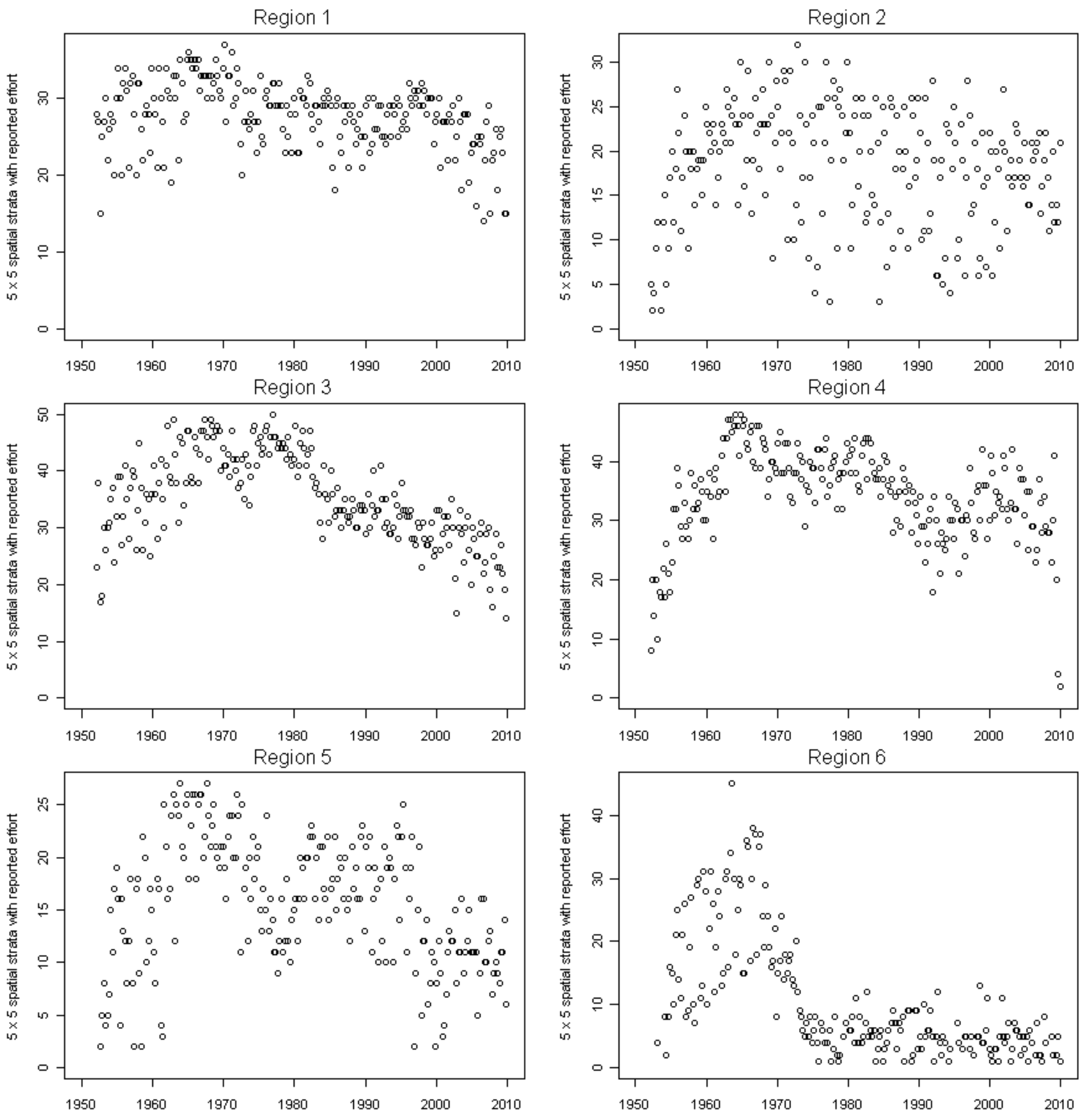

Figure 4: The number of 5° x 5°spatial strata in which effort is reported, by region and year-quarter, for the Japanese distant-water longline fleet, as recorded in the aggregated dataset.

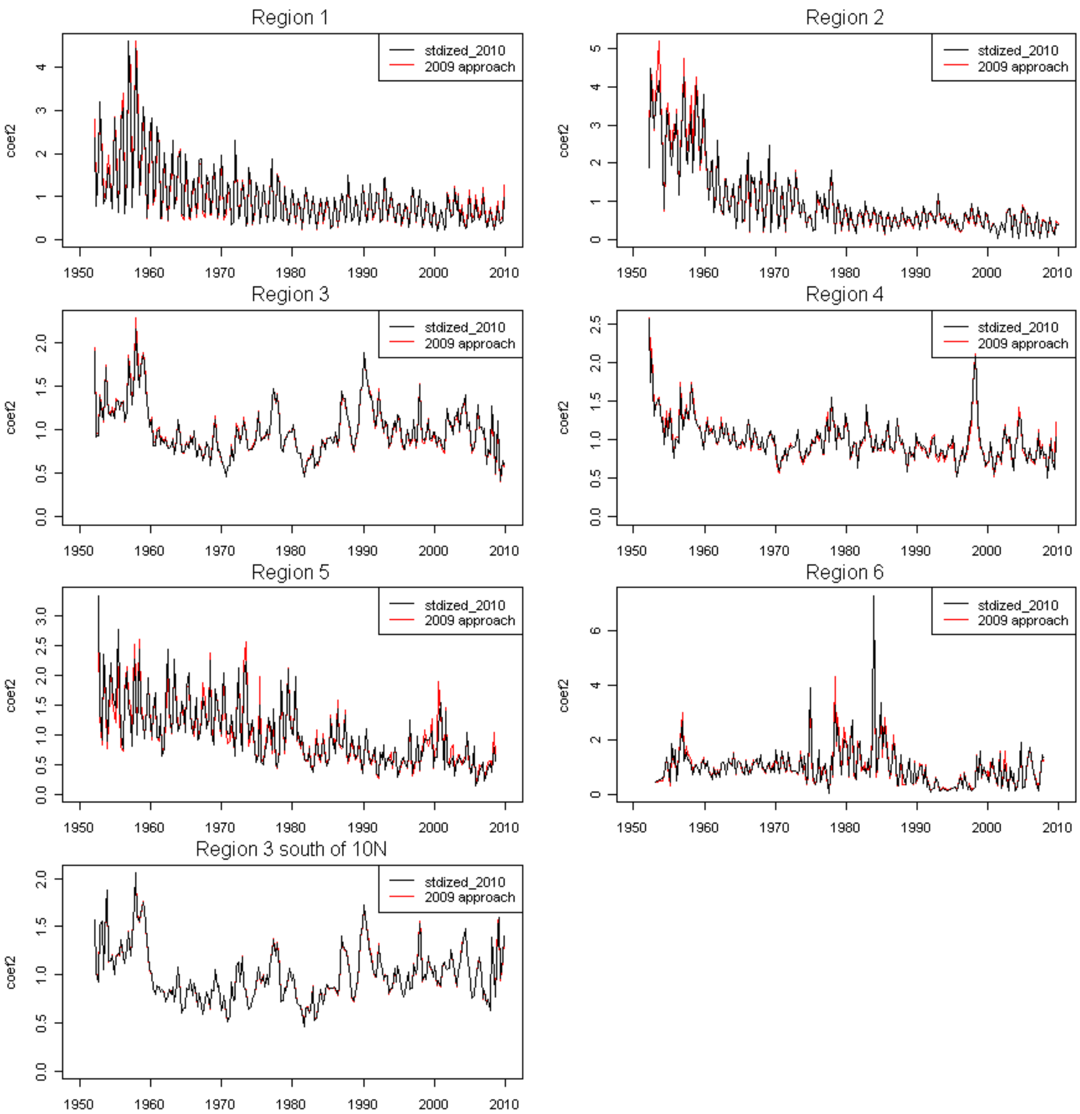

Figure 5: Standardized indices of bigeye CPUE by region, estimated using the 2010 approach (black) and the 2009 approach which included yellowfin CPUE with an abundance offset (red).

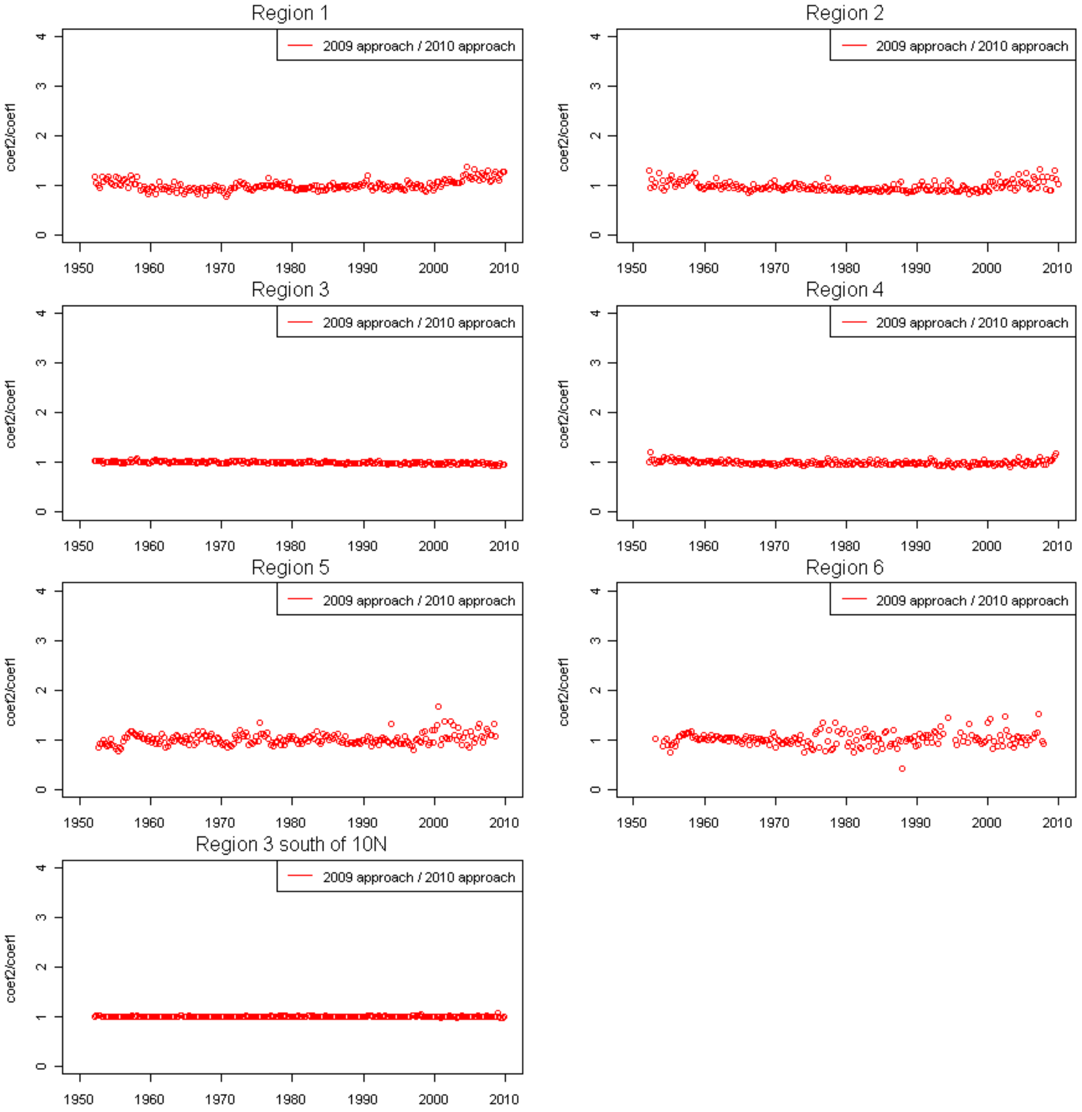

Figure 6: Ratios of the 2010 bigeye indices and indices from the 2008 approach, by year-quarter and region.

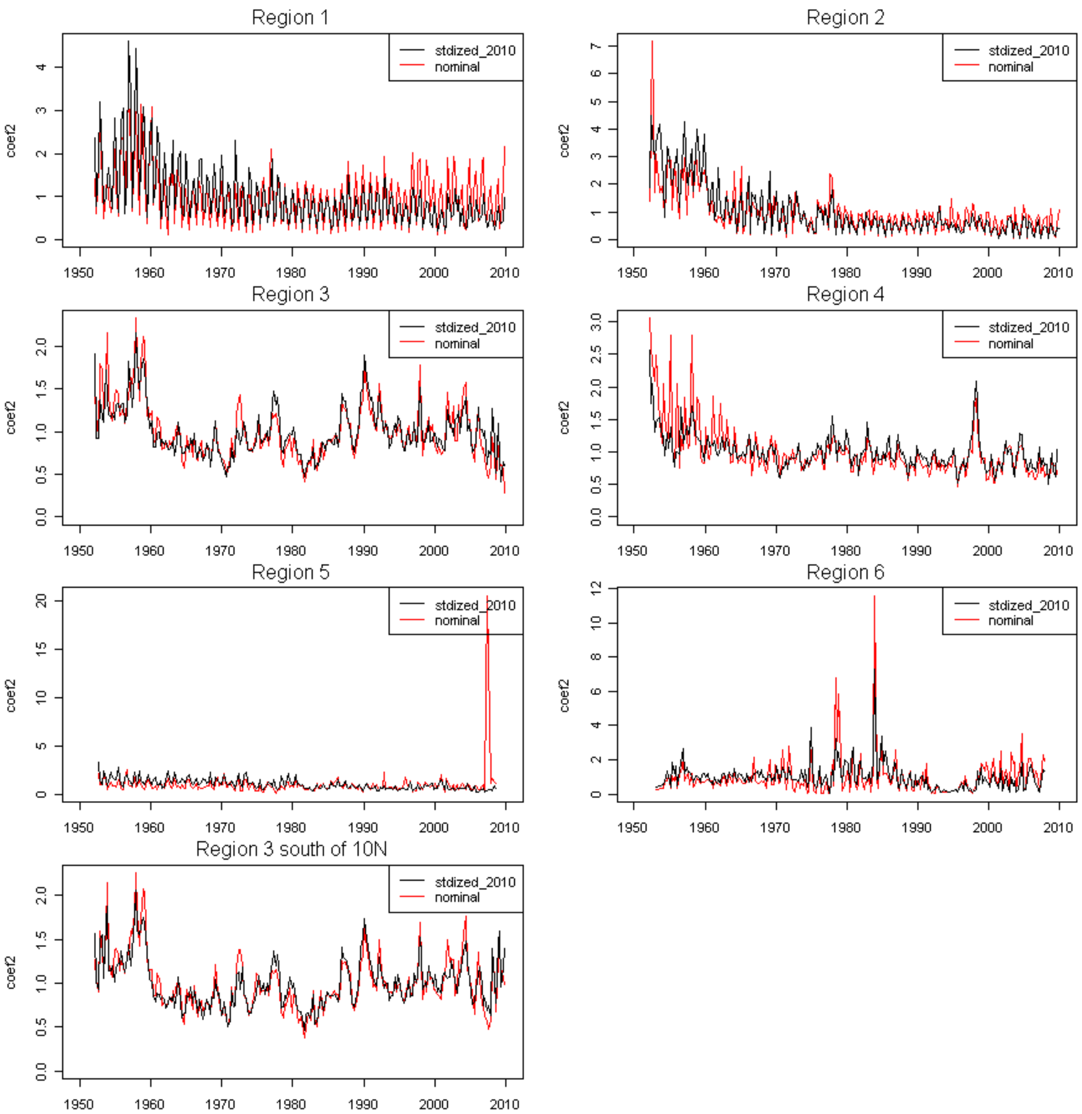

Figure 7: Indices of bigeye CPUE by region, comparing the 2010 bigeye indices (black) with nominal CPUE indices (red).

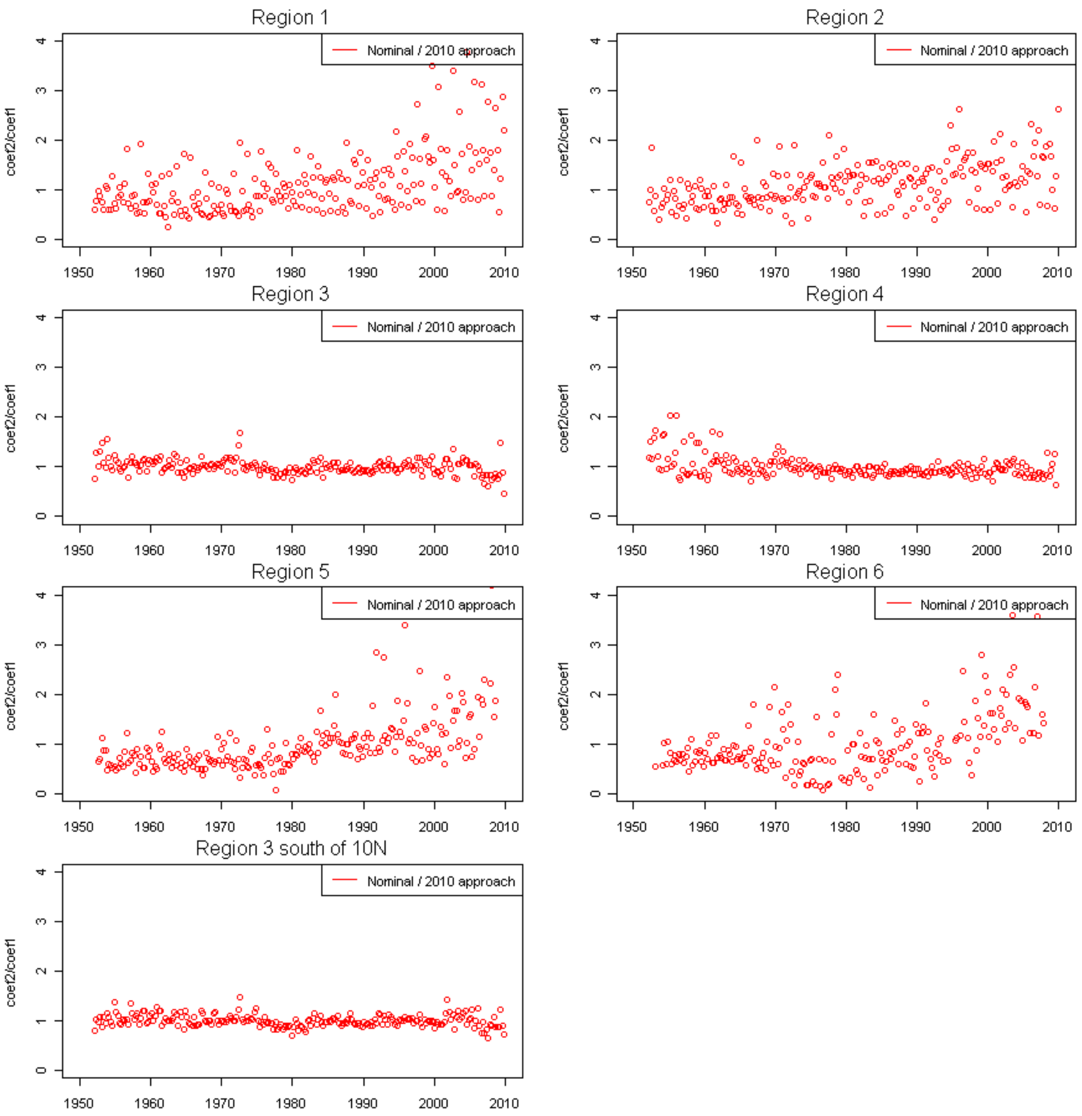

Figure 8: Ratios (2010 approach vs nominal CPUE) of bigeye CPUE indices, by year-quarter and region.

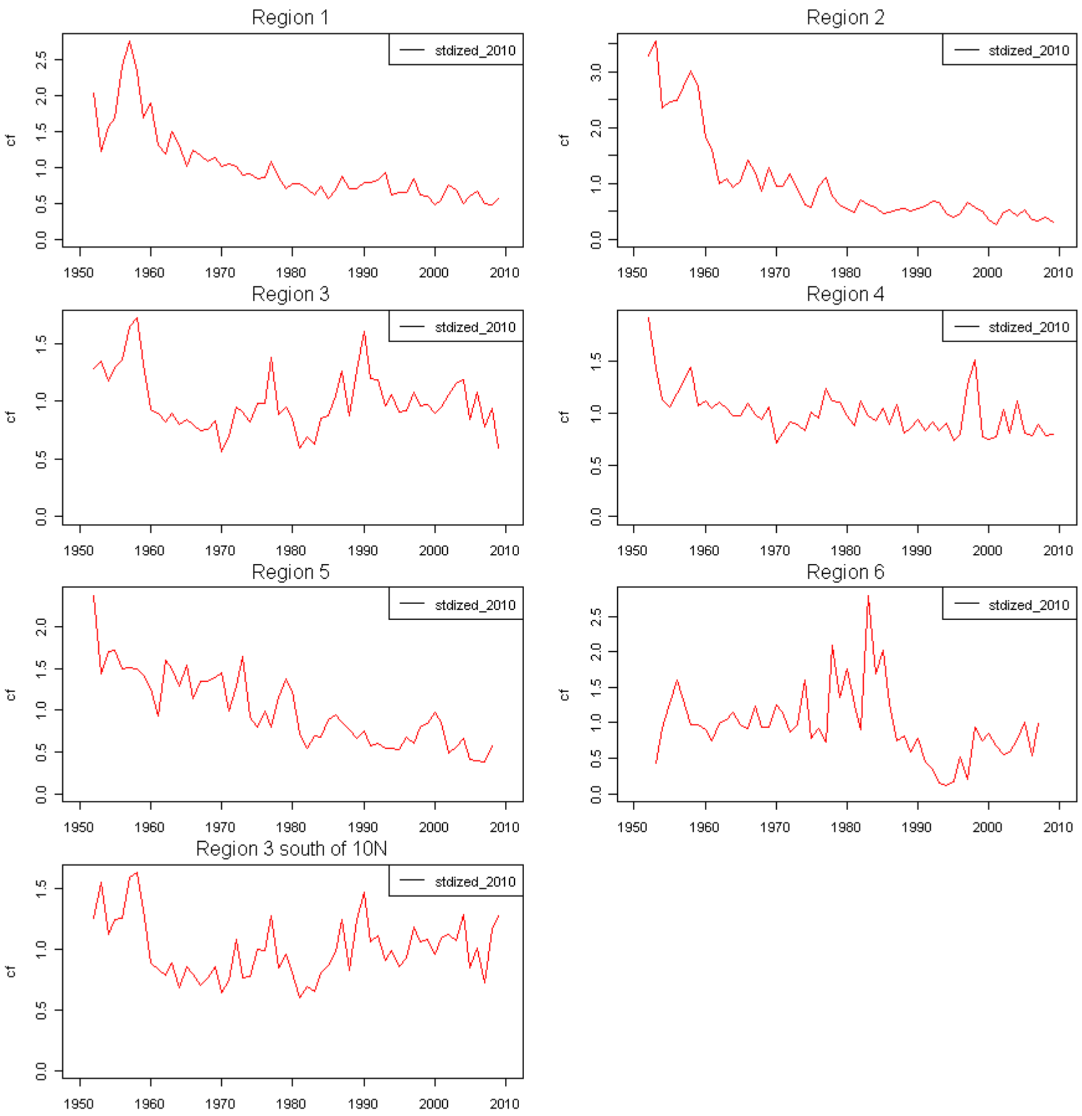

Figure 9: Annualised indices of abundance for bigeye tuna.

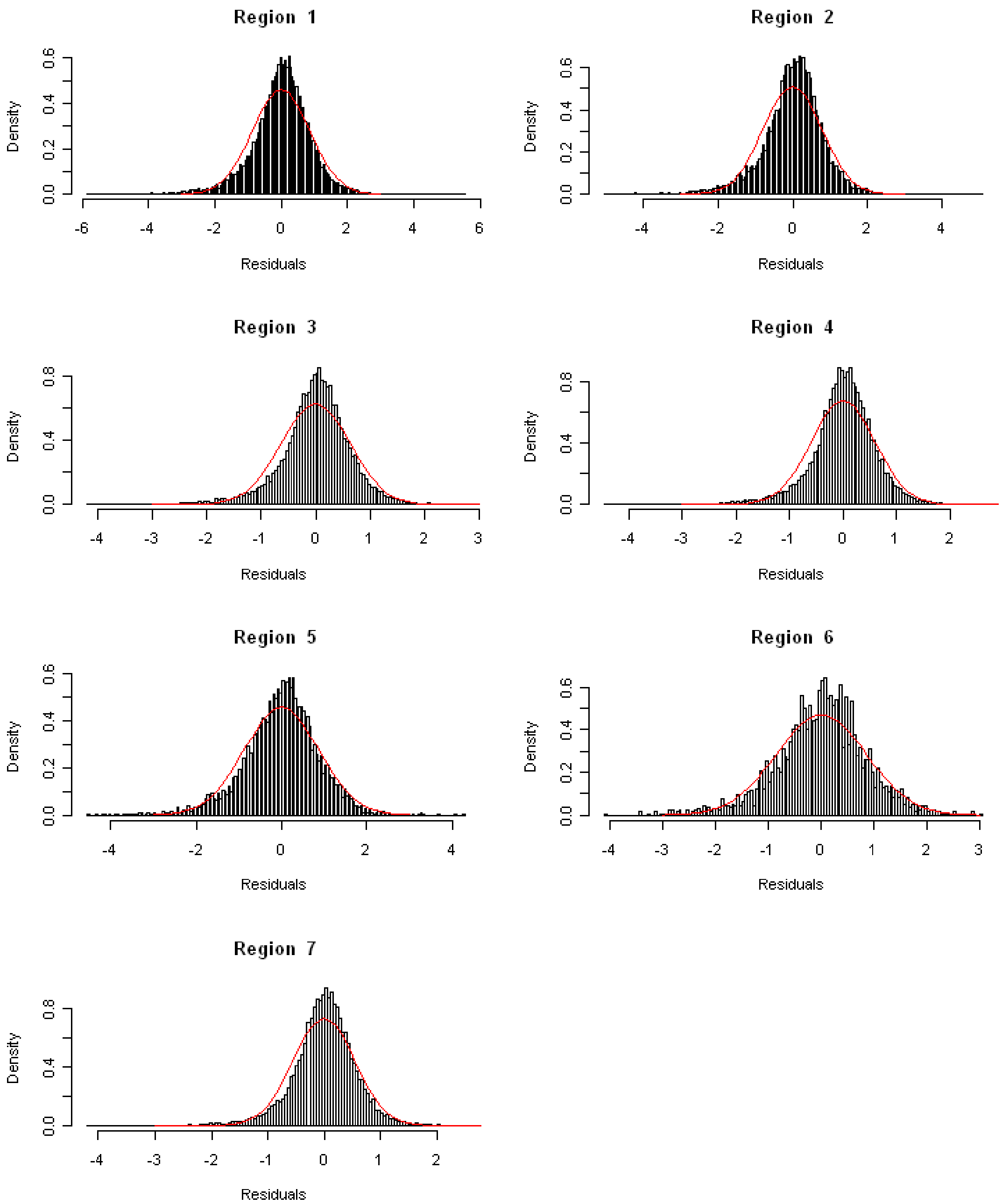

Figure 10: Density histograms of residual sizes by region from the GLMs used to estimate the 2010 bigeye indices (black), compared with a normal distribution with mean zero and the same standard deviation as the residuals. The distribution shows positive kurtosis and negative skewness, with more negative residuals than are assumed by the normal distribution.

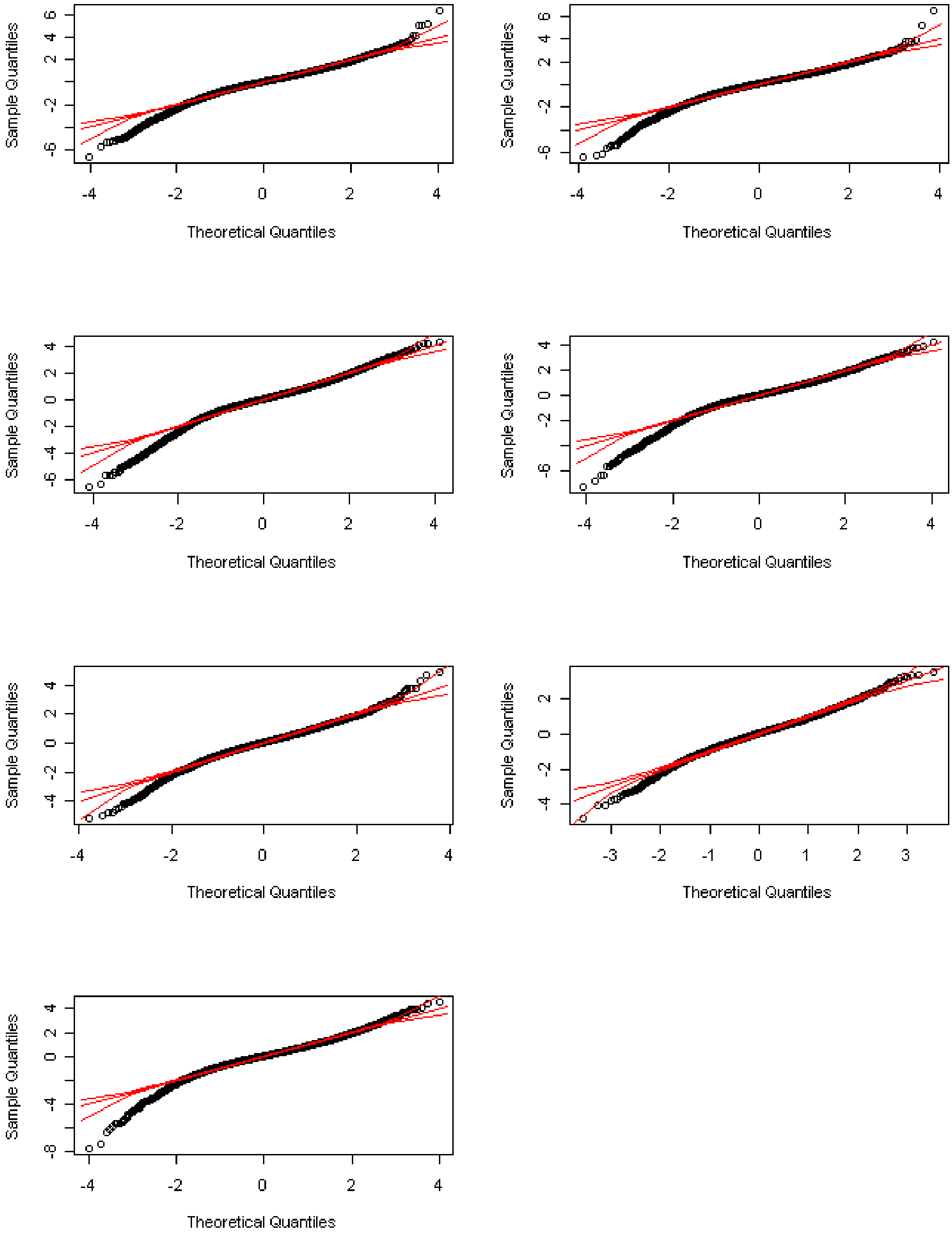

Figure 11: Q-Q plots of residuals by region from the GLMs used to estimate the 2010 bigeye indices (black), compared with the expected distribution assuming normality, with median and ± 2SD's. In each case the negative residuals are more extreme than expected.

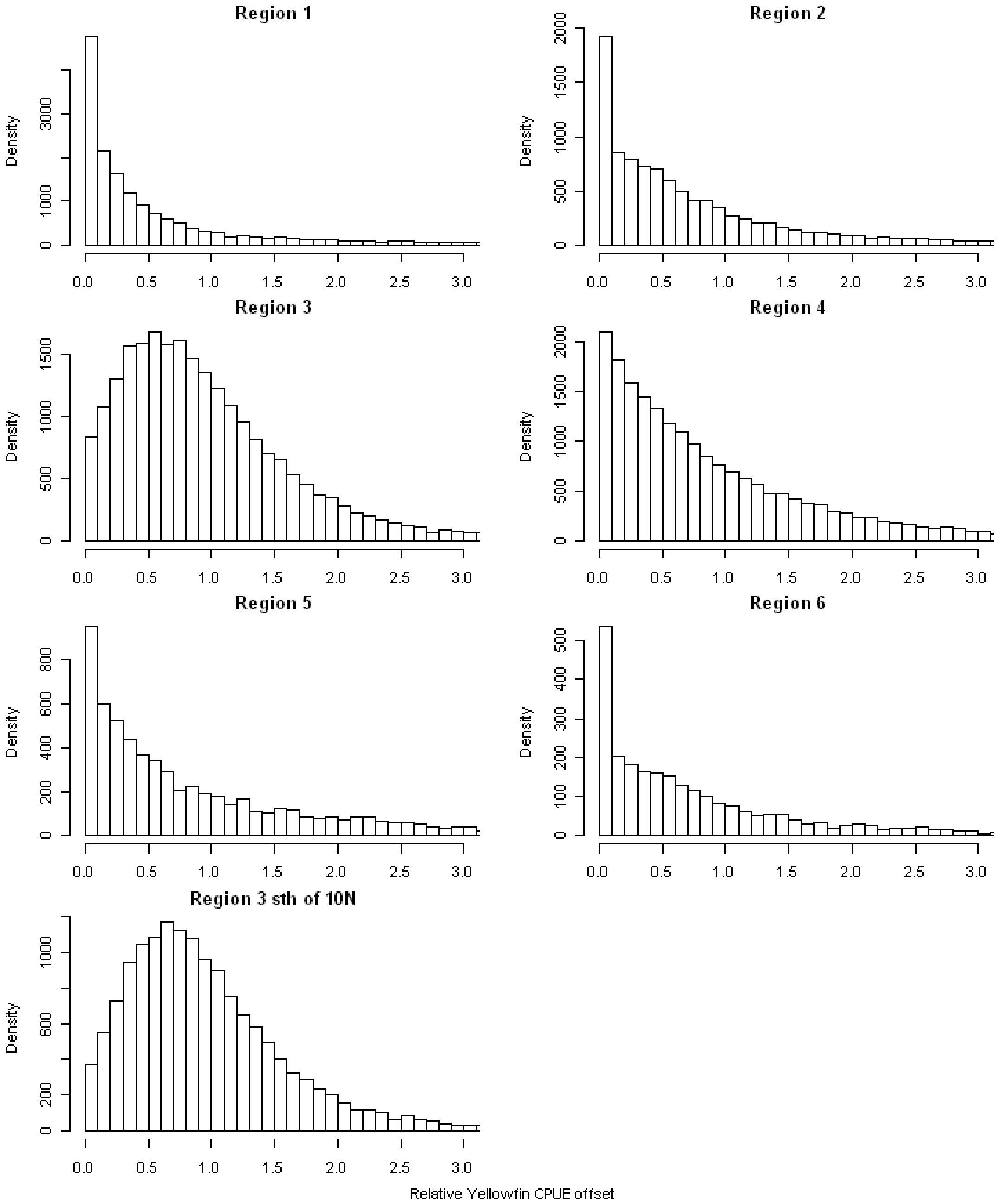

Figure 12: Frequency distribution of bigeye targeting indicators based on the catch rate of yellowfin, offset by yellowfin abundance.

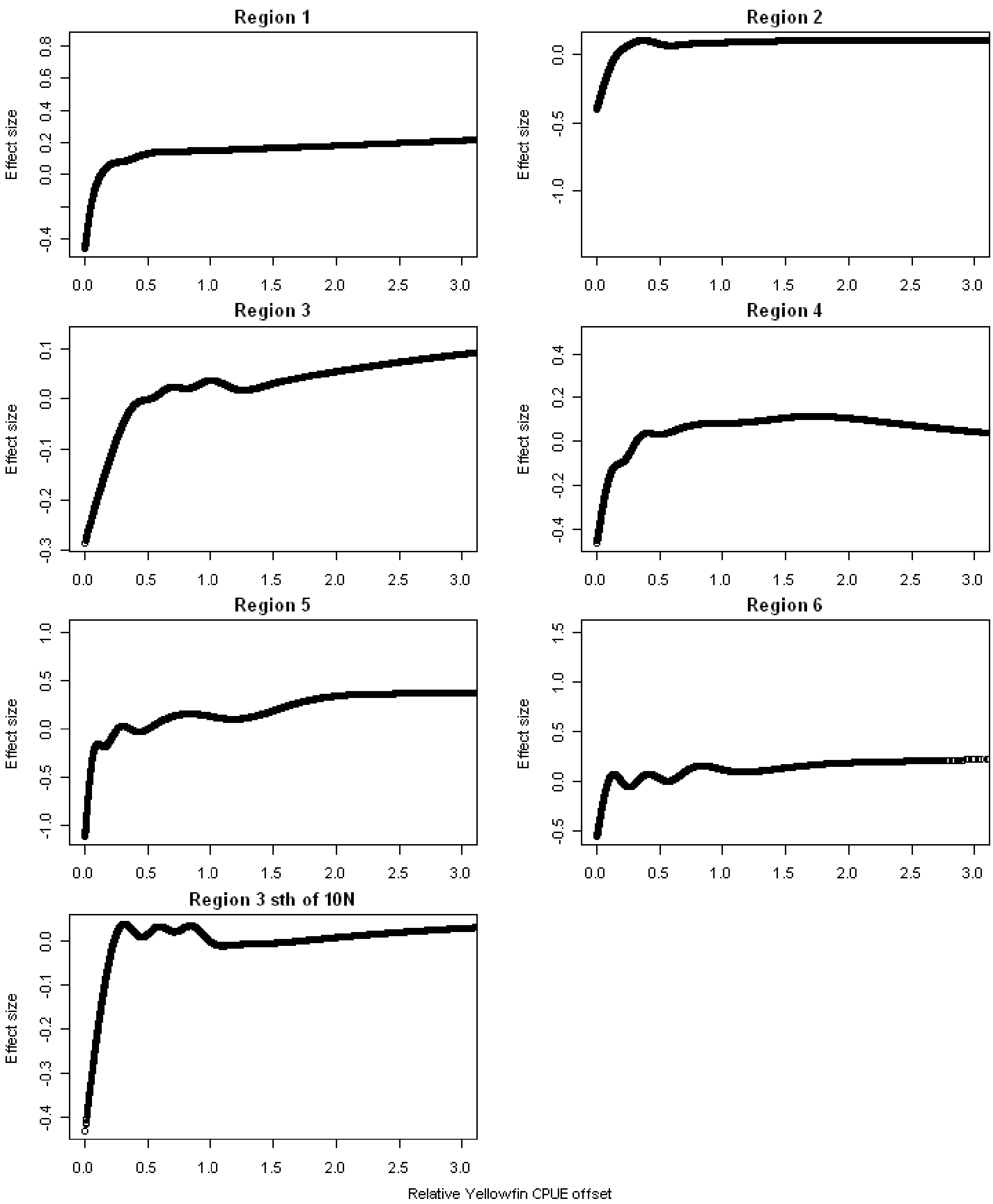

Figure 13: Estimates of the relationship between bigeye catch rate and the targeting indicator based on the catch rate of yellowfin, offset by yellowfin estimated abundance.

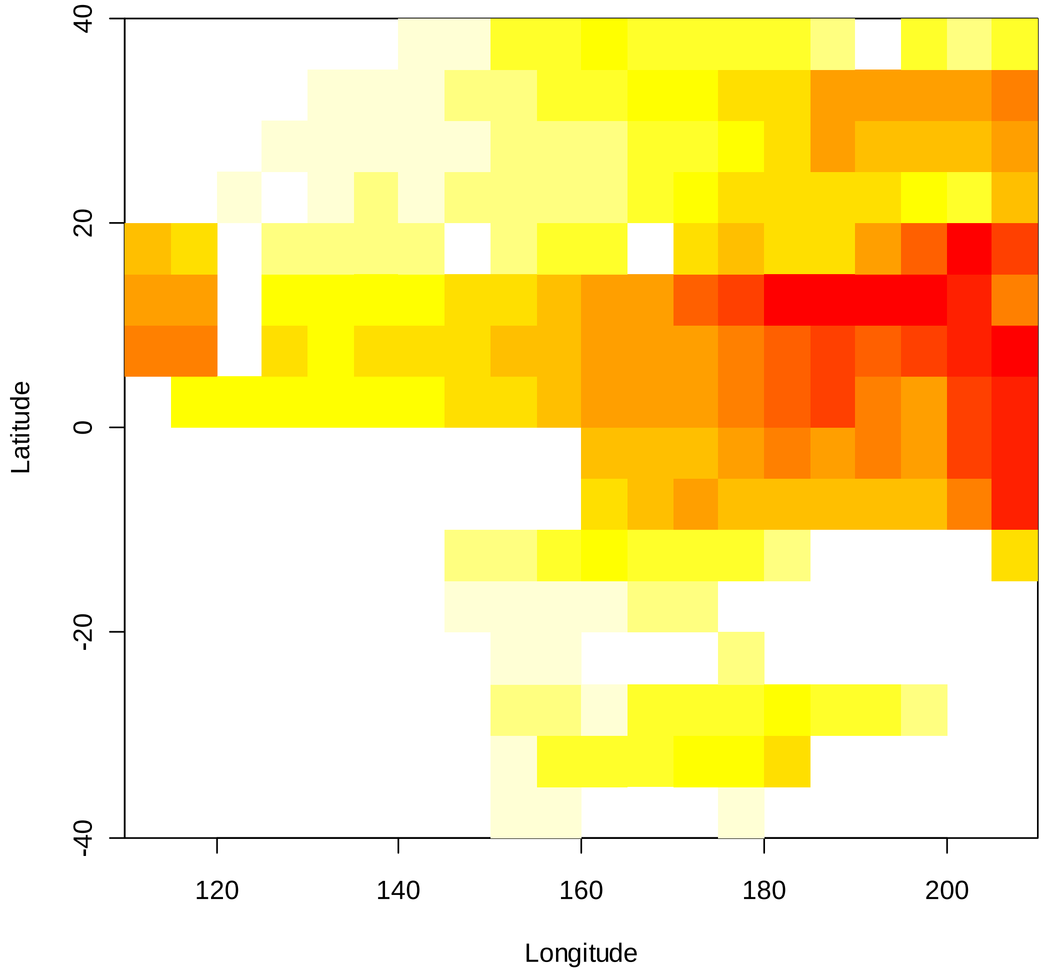

Figure 14: Spatial distribution of bigeye tuna catch rates, as estimated in the regional rescaling analysis. Darker colours signify higher catch rates.

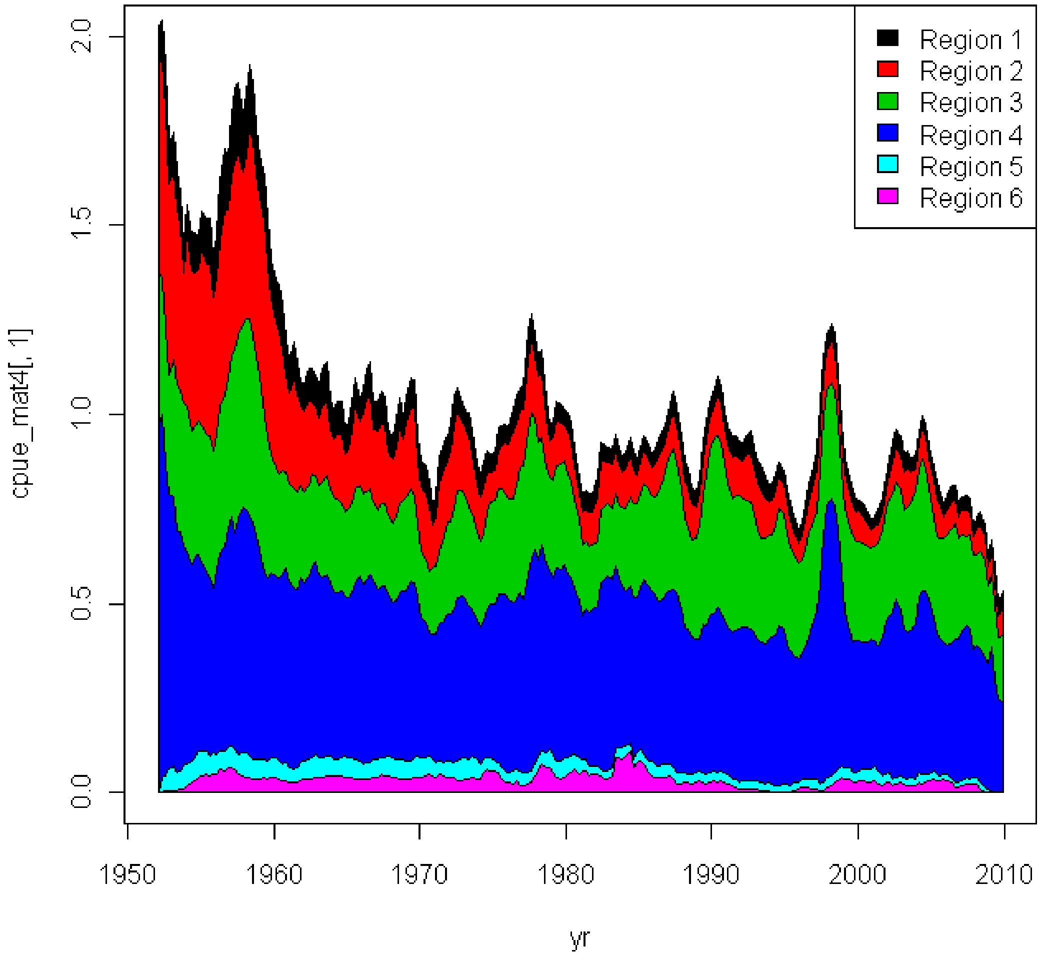

Figure 15: Indices of bigeye abundance through time for all regions, adjusted by regional scaling factors. Bigeye abundance for region 3 is based on the full region.

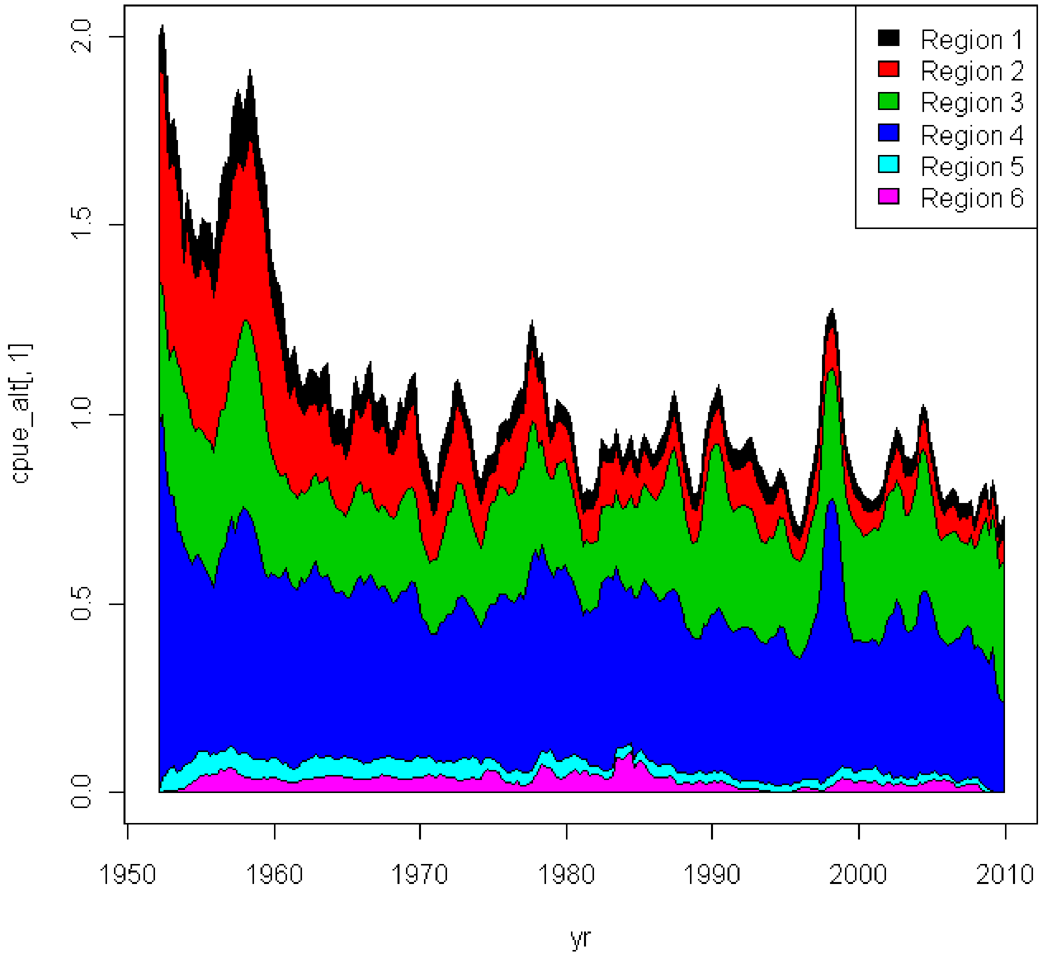

Figure 16: Indices of bigeye abundance through time for all regions, but with bigeye abundance south of 10N in region 3, adjusted by regional scaling factors..

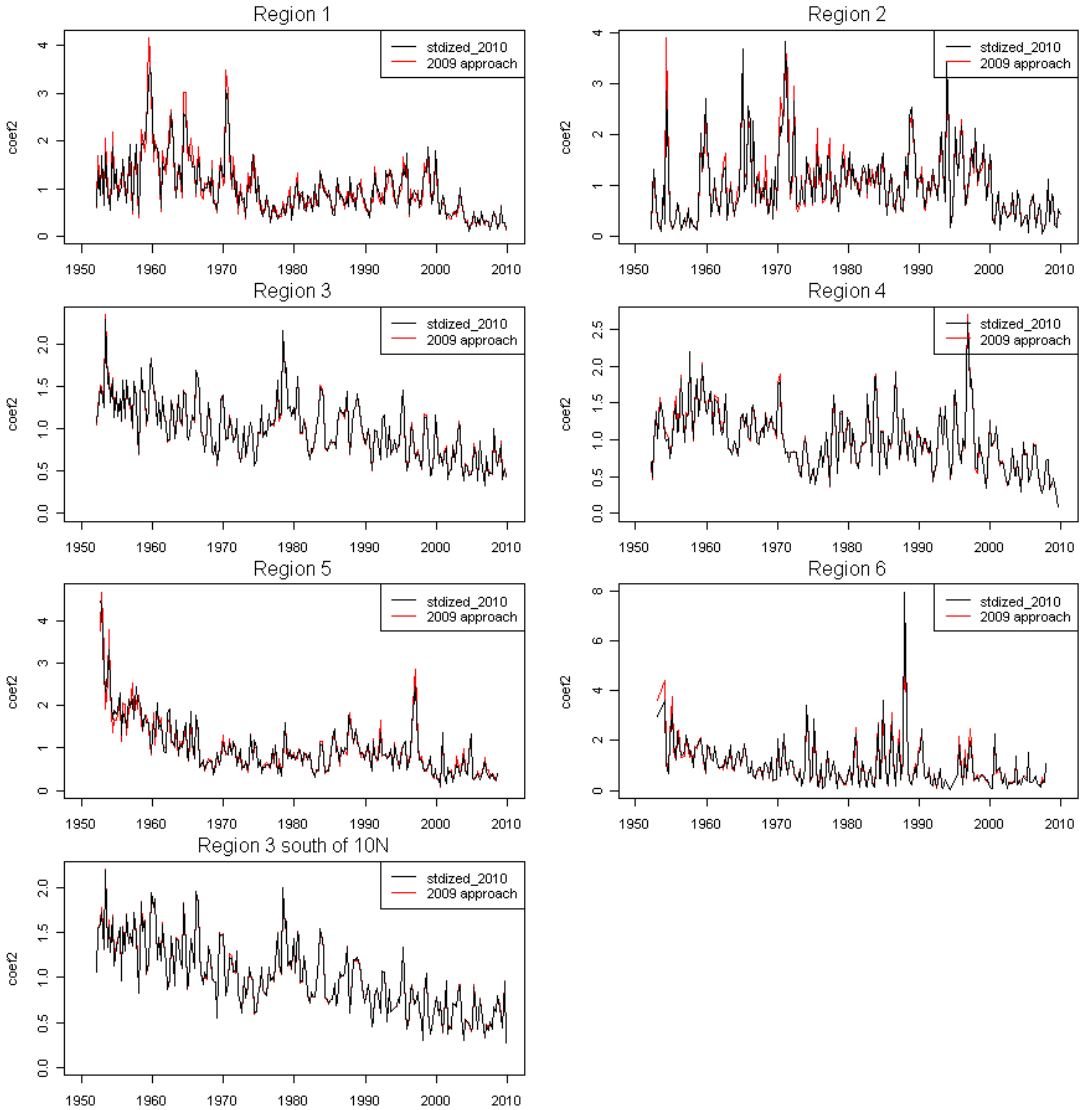

Figure 17: Standardized indices of yellowfin CPUE by region, estimated using the 2010 approach (black) and the 2009 approach which included a targeting indicator based on bigeye CPUE (red).

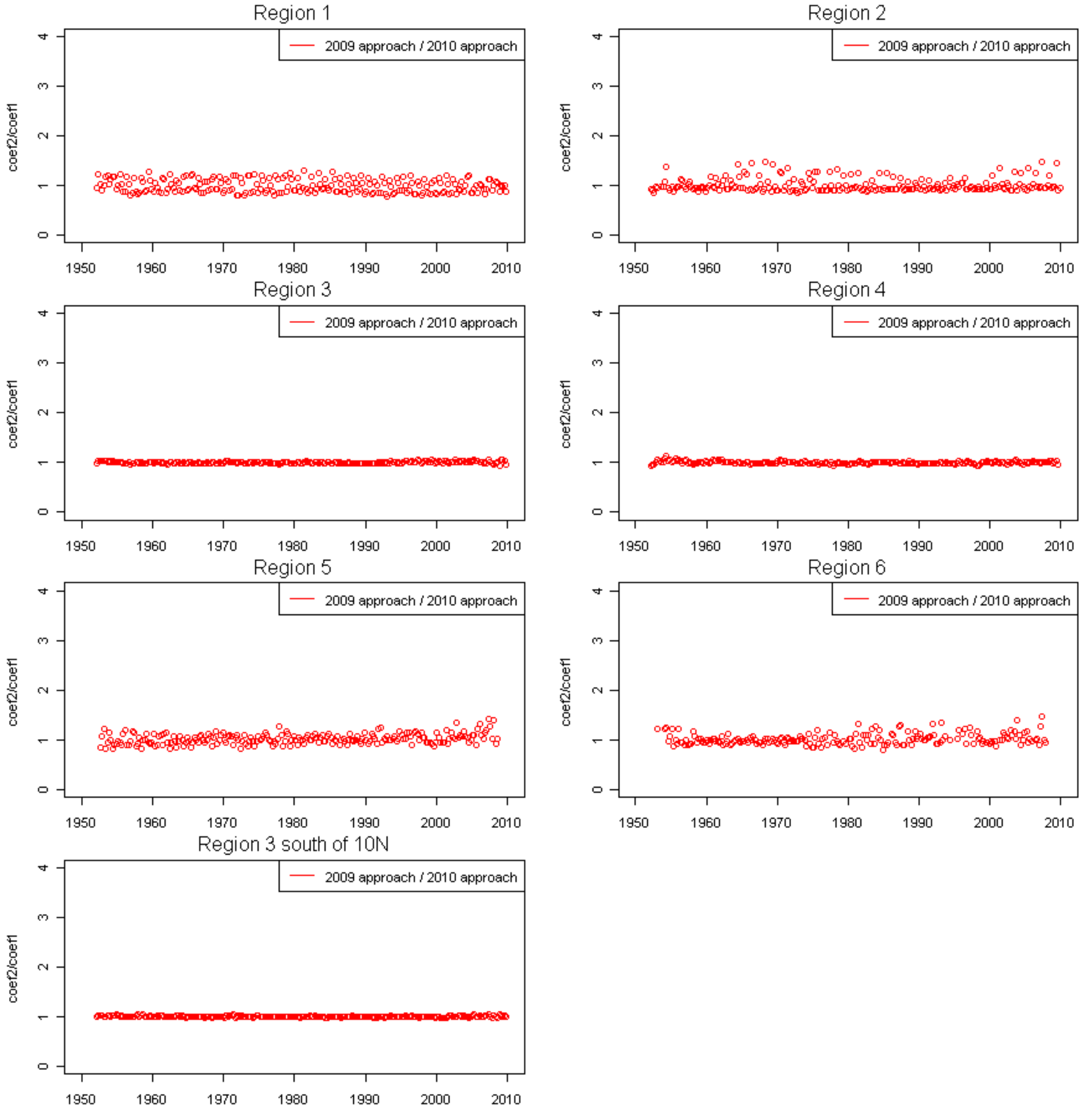

Figure 18: Ratios (2010 approach vs 2009 approach) of yellowfin CPUE indices, by year-quarter and region.

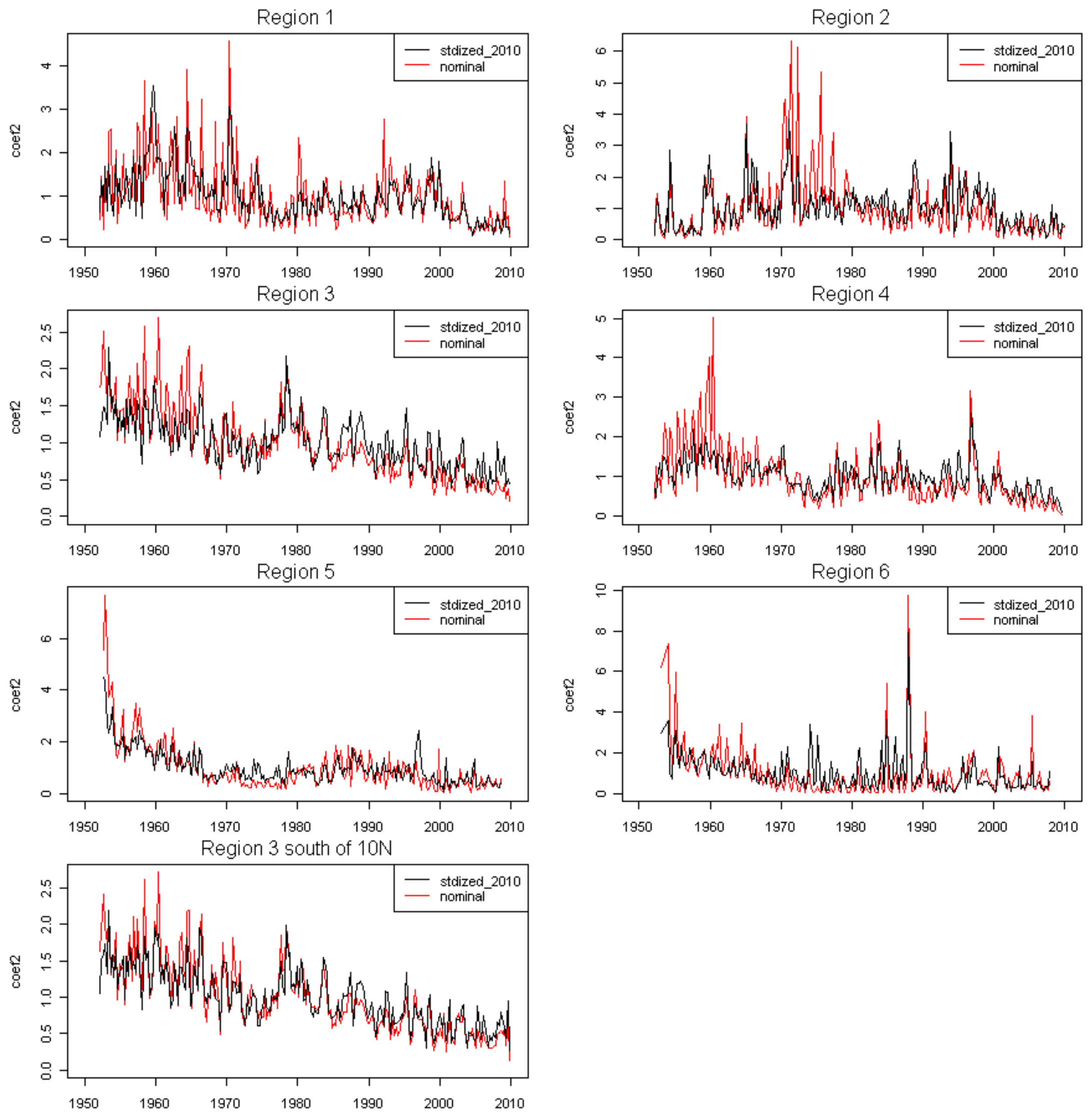

Figure 19: Indices of yellowfin CPUE by region, both 2010 indices (black) and nominal (red).

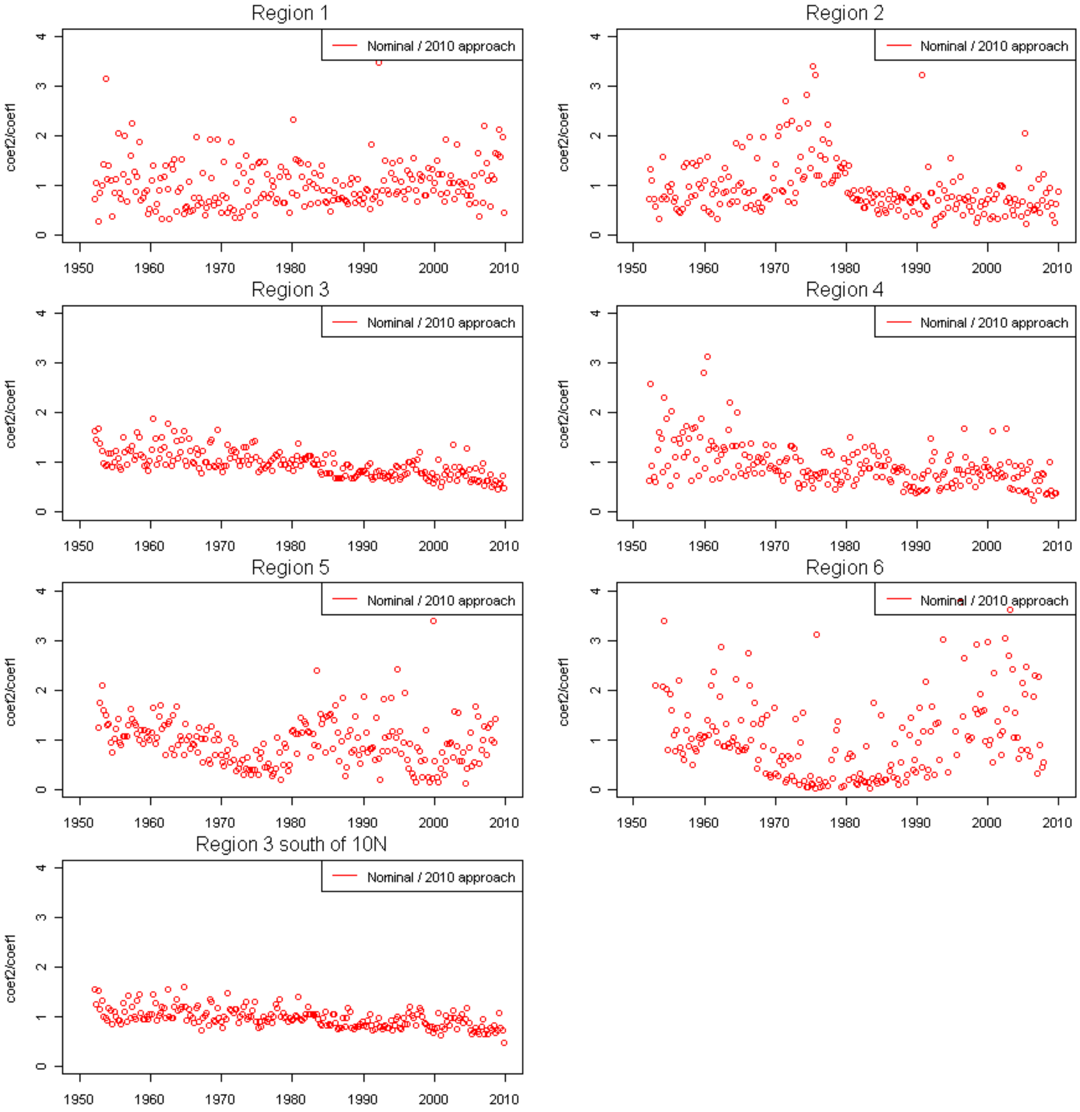

Figure 20: Ratios (2010 approach vs nominal) of yellowfin CPUE indices, by year-quarter and region.

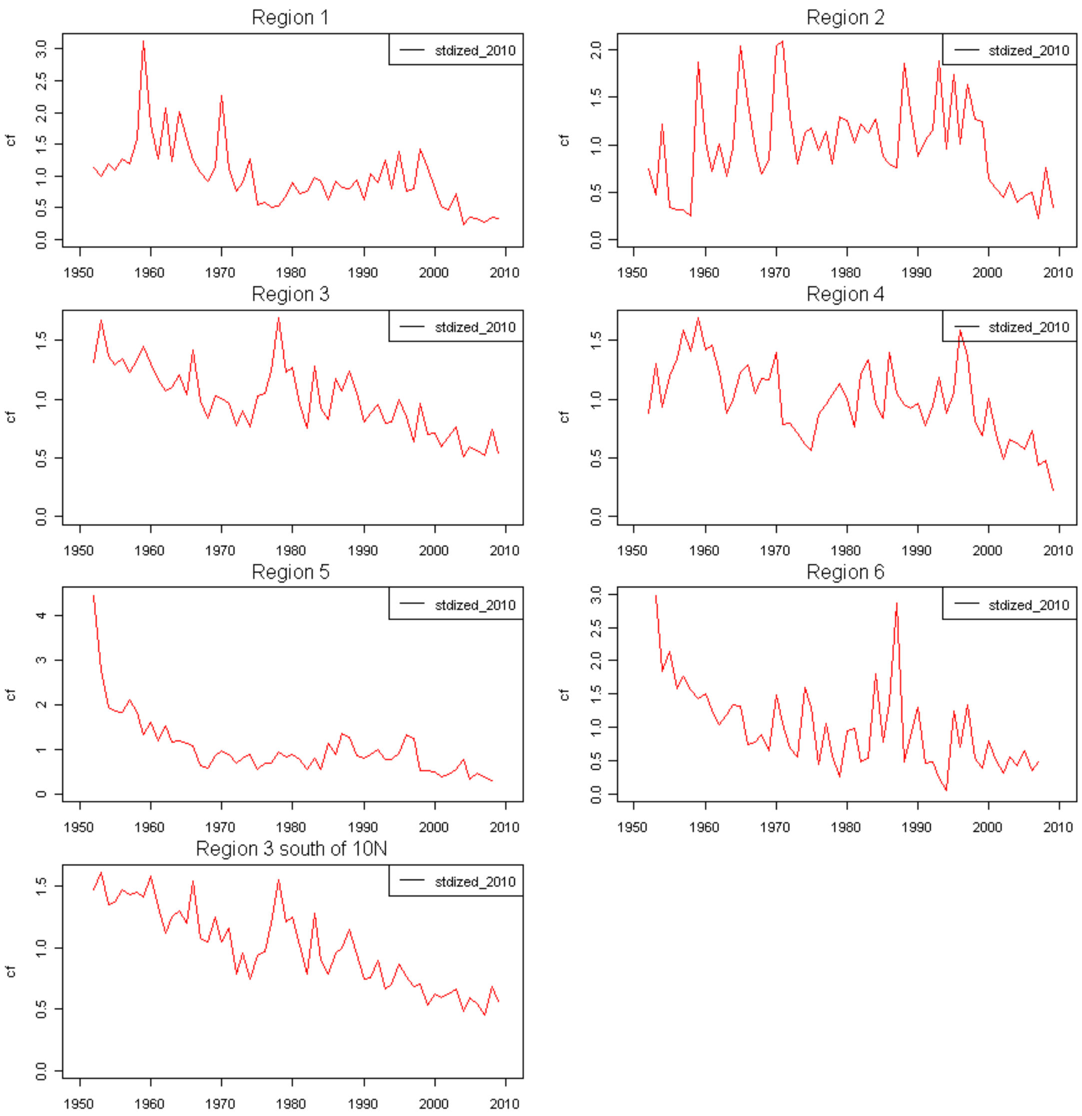

Figure 21: Annualised indices of abundance for yellowfin tuna.

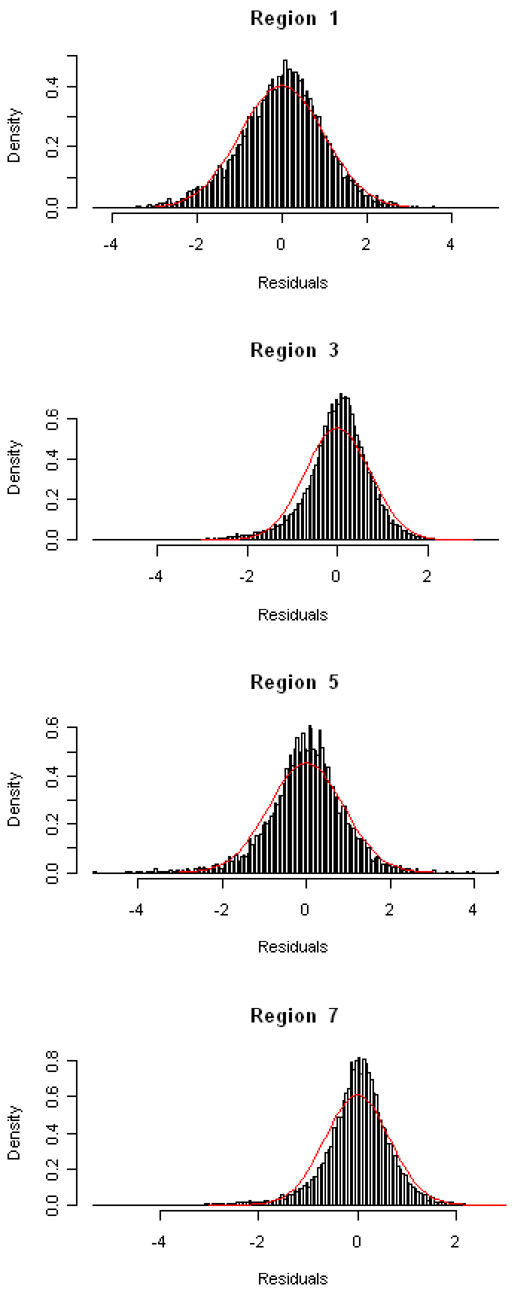

Figure 22: Density histograms of residual sizes by region from the GLMs used to estimate the 2010 yellowfin indices (black), compared with a normal distribution with mean zero and the same standard deviation as the residuals. The distribution shows positive kurtosis and negative skewness, with more negative residuals than are assumed by the normal distribution.

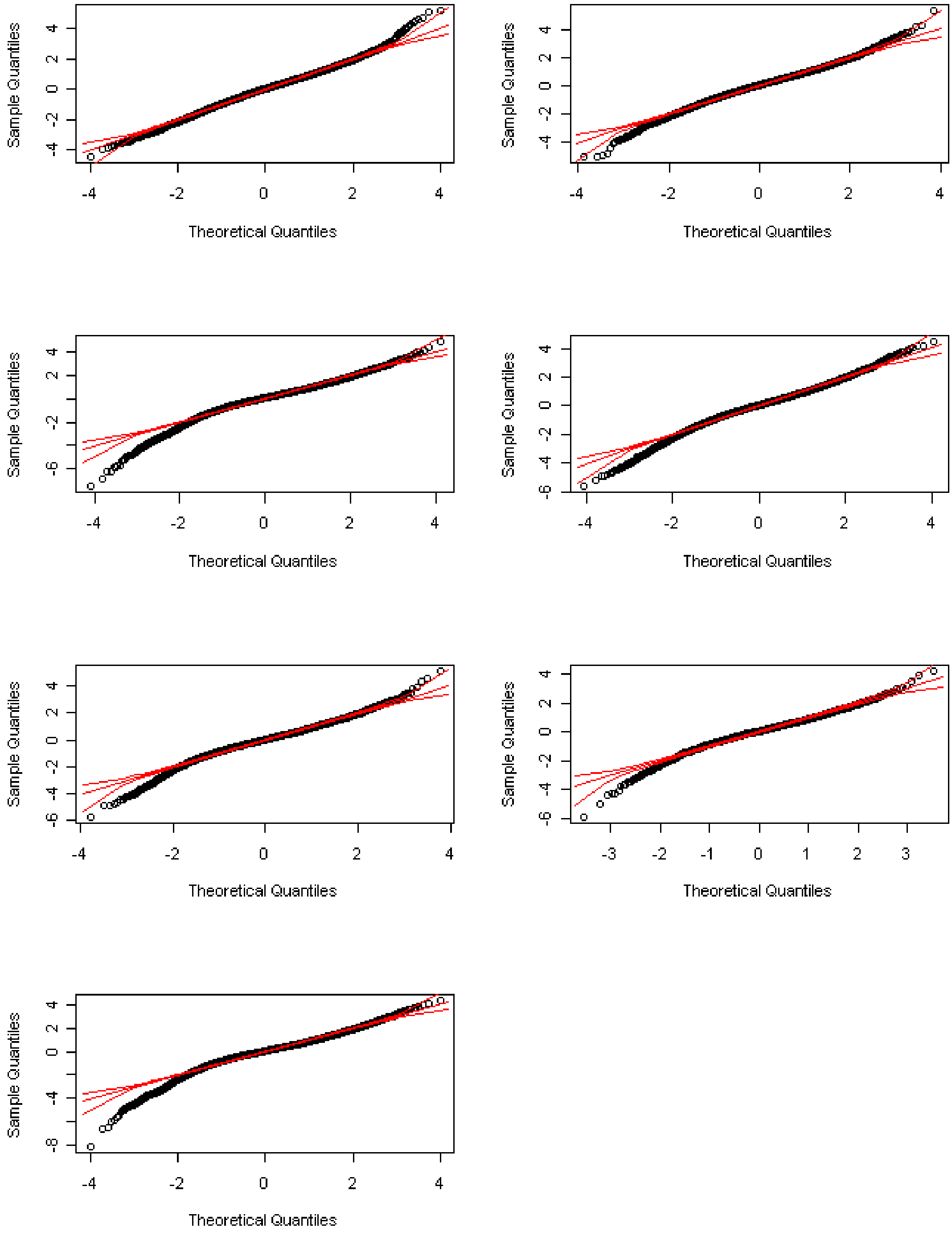

Figure 23: Q-Q plots of residuals by region from the GLMs used to estimate the 2010 yellowfin indices (black), compared with the expected distribution assuming normality, with median and ± 2SD's. In each case the negative residuals are more extreme than expected.

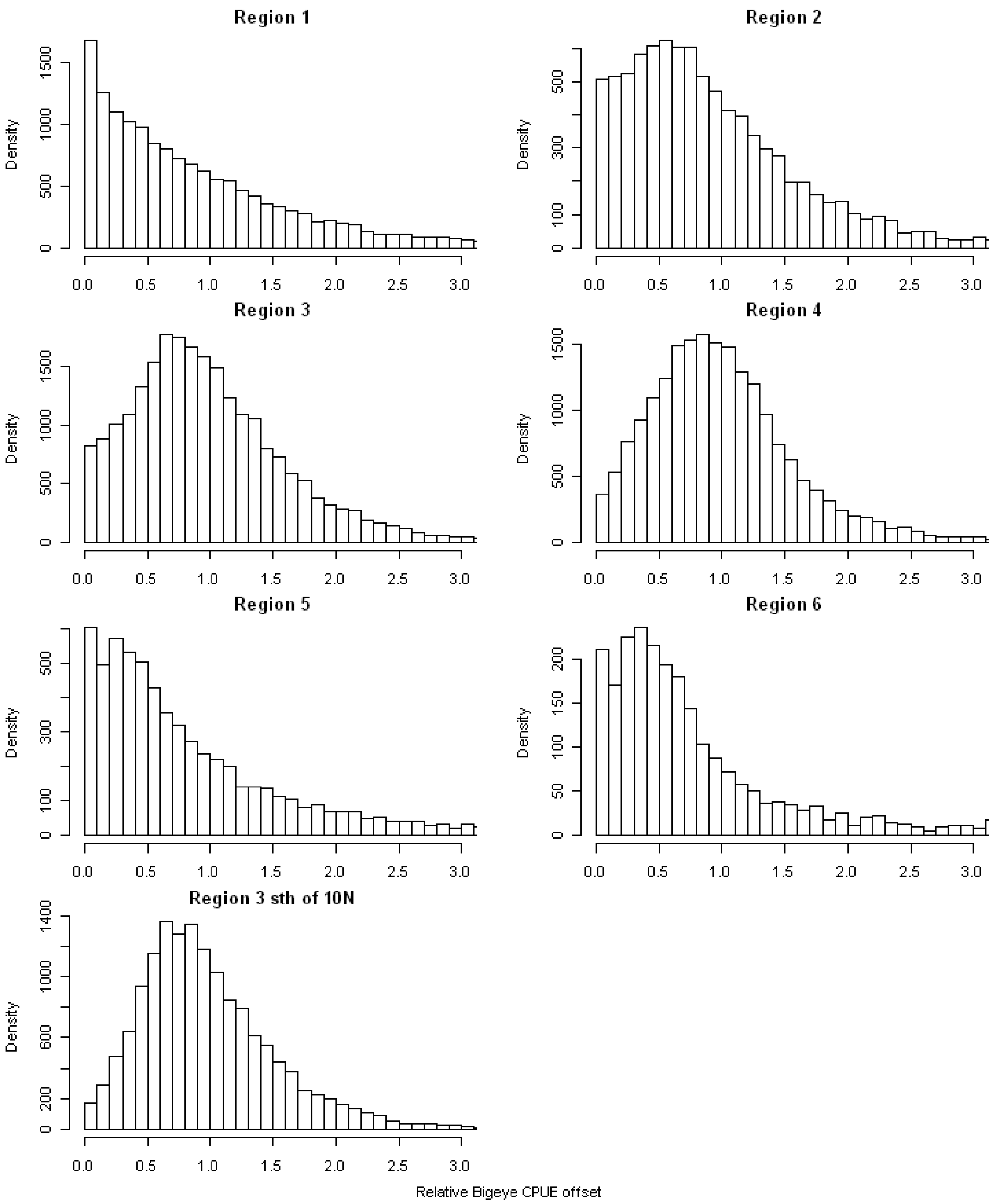

Figure 24: Frequency distribution of yellowfin targeting indicators based on the catch rate of bigeye, offset by bigeye estimated abundance.

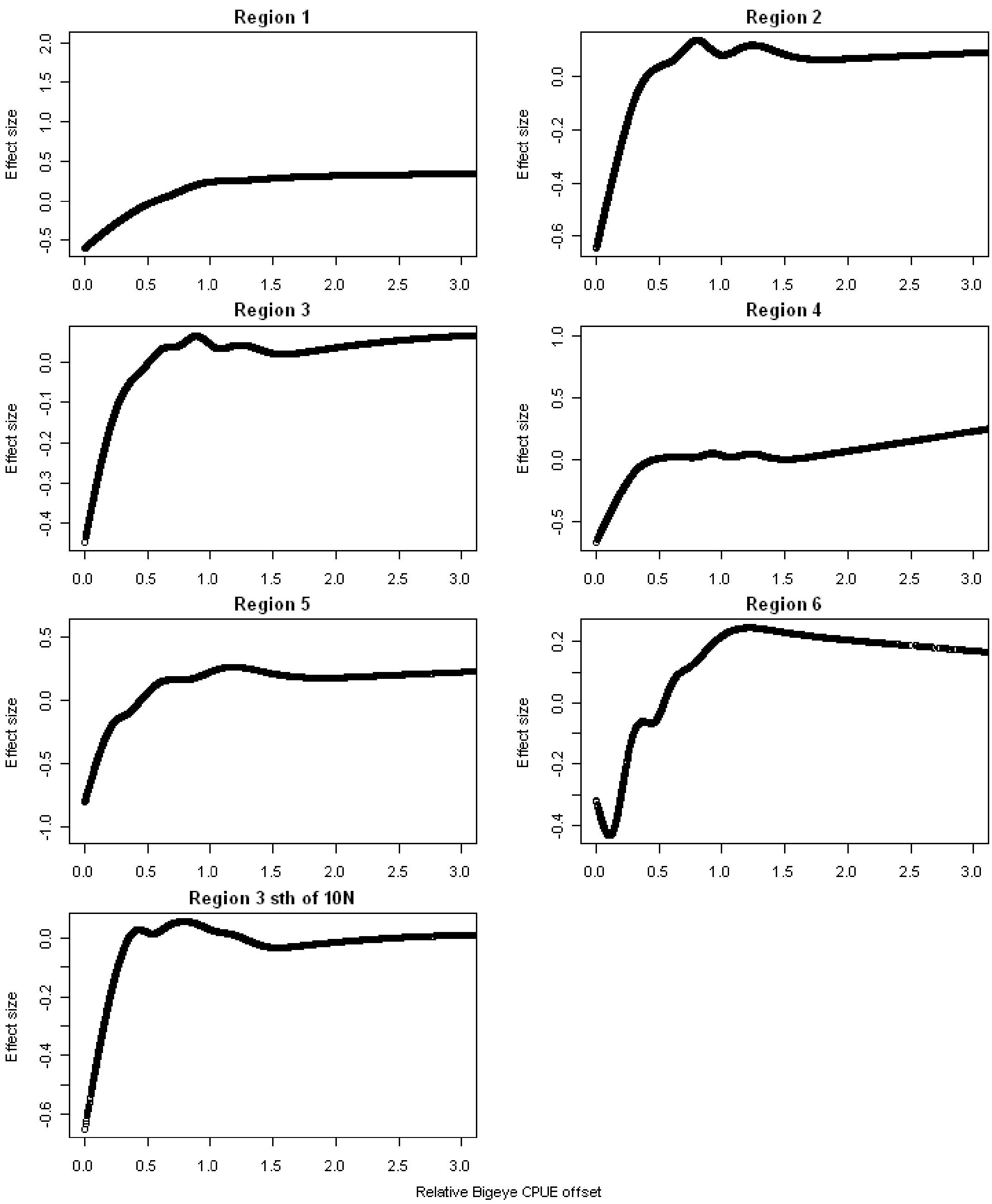

Figure 25: Estimates of the relationship between yellowfin catch rate and the targeting indicator based on the catch rate of bigeye, offset by bigeye estimated abundance.

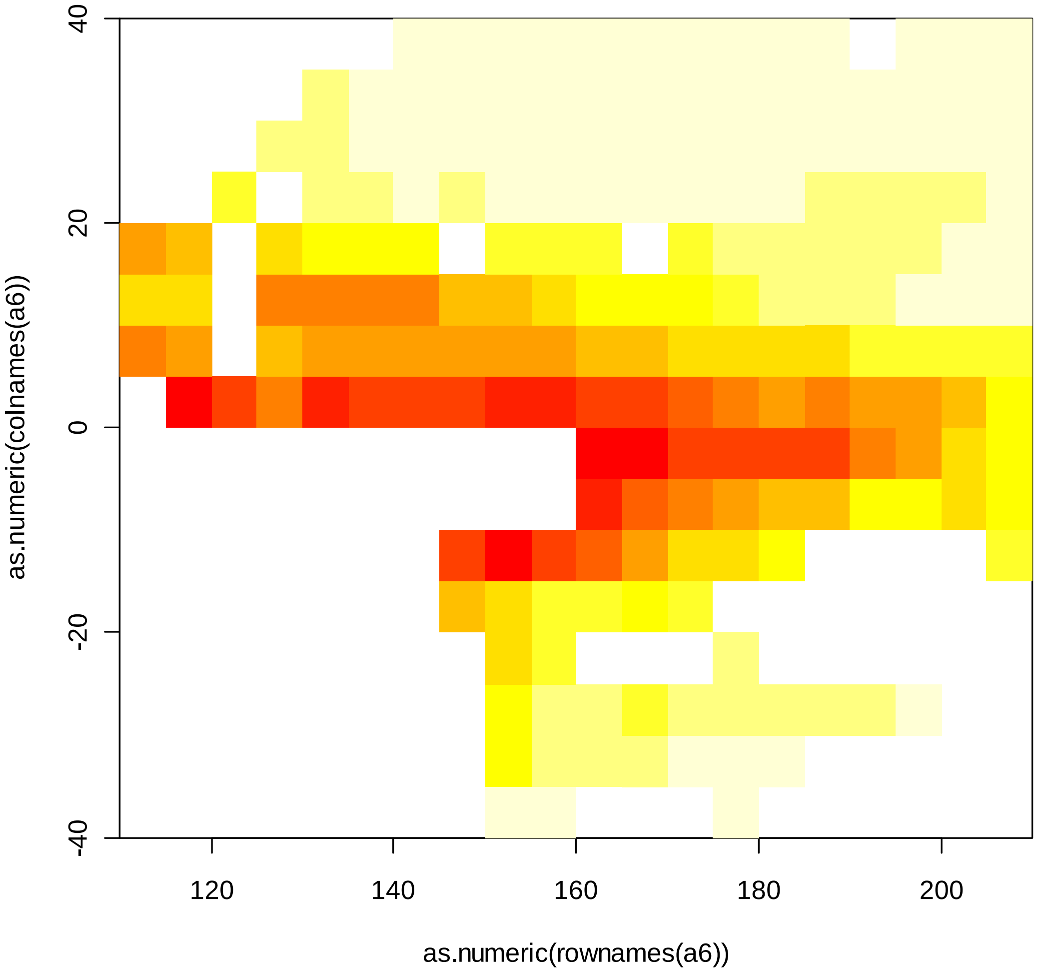

Figure 26: Spatial distribution of yellowfin tuna catch rates, as estimated in the regional rescaling analysis. Darker colours signify higher catch rates.

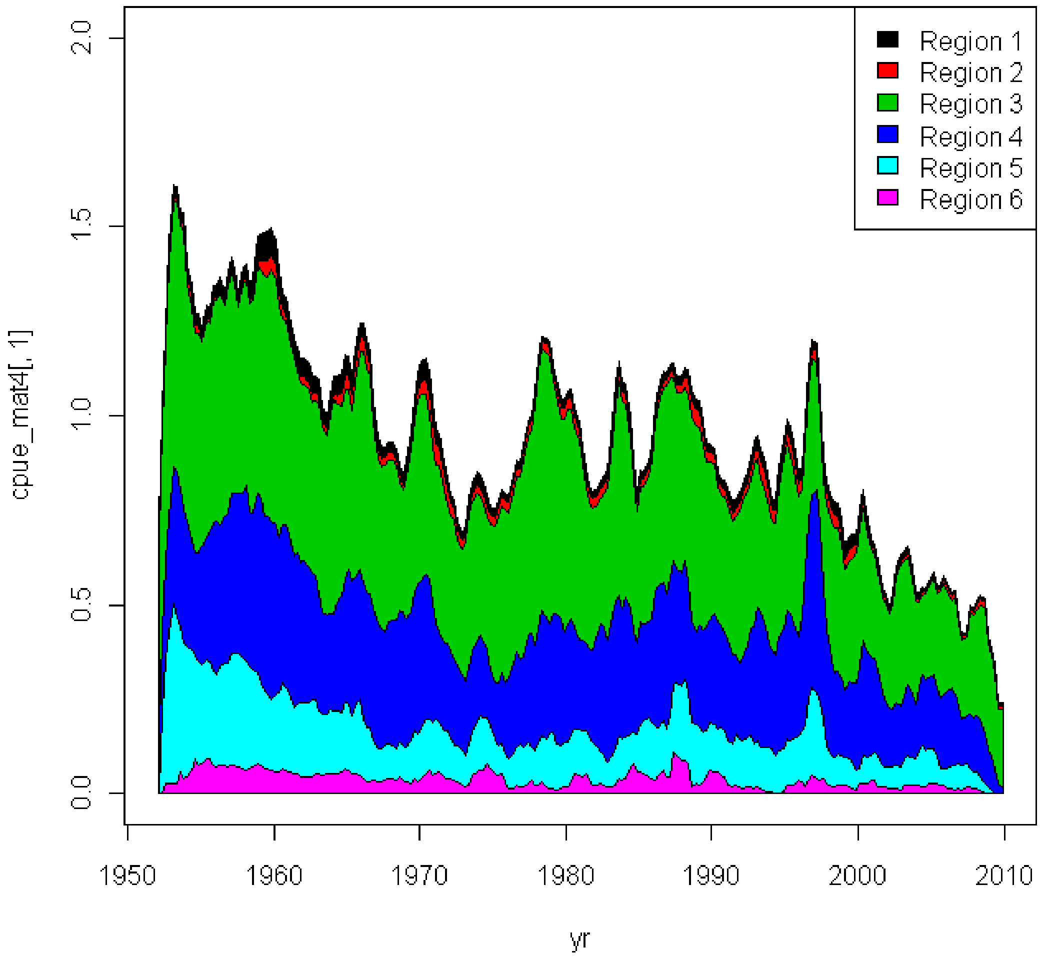

Figure 27: Indices of yellowfin abundance through time for all regions, adjusted by regional scaling factors.

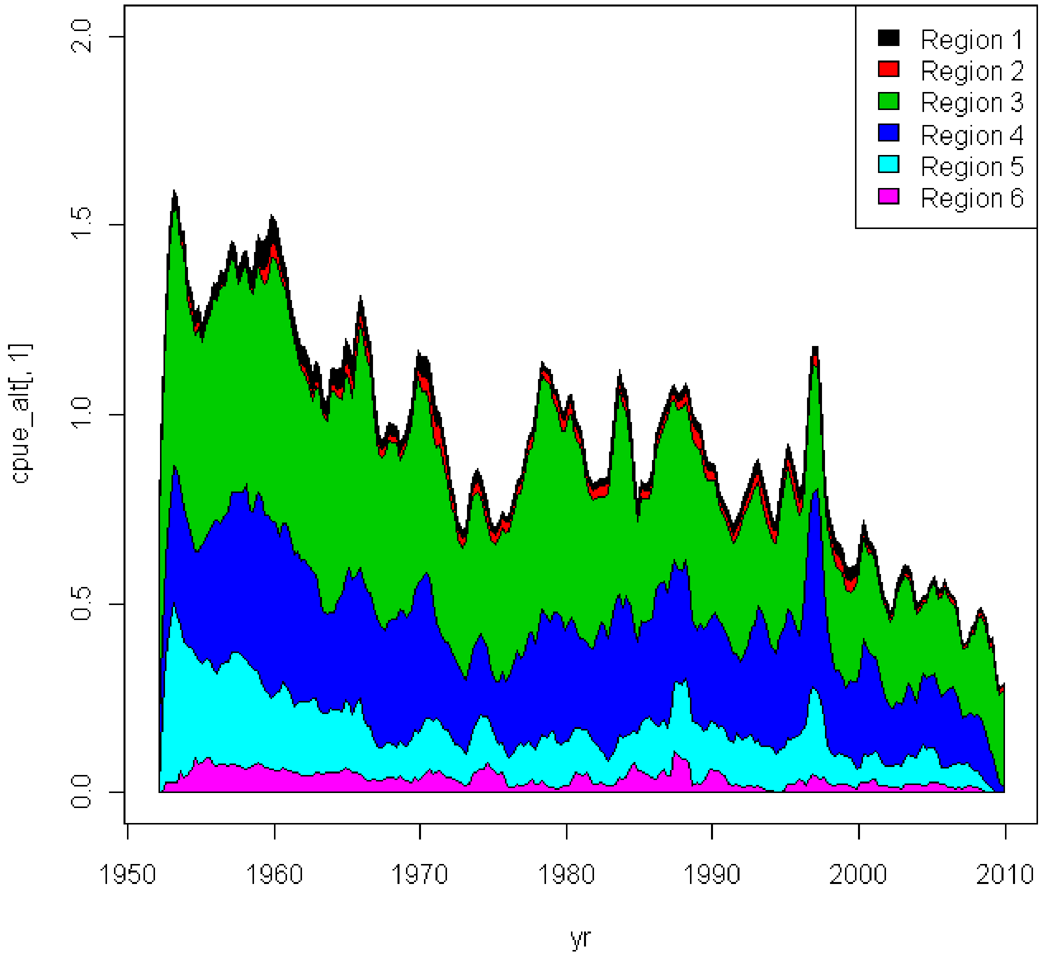

Figure 28: Indices of yellowfin abundance through time for all regions, but using the area south of 10N for region 3, adjusted by regional scaling factors