Fishery-dependent CPUE index for bluefish derived from MRIP data

Katie Drew, ASMFC
June 2022

Summary

The Marine Recreational Information Program (MRIP) dockside intercept program dataset was used to develop recreational catch per unit effort (CPUE) as an index of abundance for bluefish. Two methods of sub-setting the data were explored: a directed trips approach, where "bluefish trips" were identified as trips where the anglers reported targeting or catch bluefish, and a species guild approach, where "bluefish trips" were identified on the basis of the presence of species that were caught most frequently with bluefish. Both indices showed similar trends overall, but the guild trips approach had more contrast in the time series. The WG chose the guild trips approach to develop the MRIP index of abundance for the base case.

Methods

Because MRIP is not designed to track effort for any one species, it can be hard to determine which of the intercepted trips with zero catch should be considered a "bluefish trip" (i.e., a trip that would be expected to catch bluefish and should be included in the CPUE calculations to track abundance) and which trips are not expected to catch bluefish and thus should be excluded from the analysis.

The directed trips method was used in SARC 41 and SARC 60 for bluefish (Northeast Fisheries Science Center 2015). A bluefish trip was defined as a trip where the angler reported targeting or catching bluefish.

The weakness of the directed trips classification is that anglers report their target species when they are intercepted, after they have returned from a trip. Only 34% of trips that caught bluefish reported targeting bluefish, and 15% of trips that caught bluefish did not specify a target species at all. As a result, this method is likely missing trips that could have caught bluefish but did not, i.e., missing zero-catch records.

The SARC 60 Review Panel and WG identified exploring a species association or guild approach to identifying bluefish trips as a high priority research recommendation for this assessment. The WG developed this guild approach as an alternative to the directed trips approach.

Species associations were calculated using the *jaccard* package in R (Chung et al. 2018). The *jaccard* package calculates the Jaccard/Tanimoto similarity coefficients between binary (presence-absence) vectors and uses a bootstrapping approach to determine whether those similarity coefficients are statistically significant. Species with significant positive associations with bluefish were identified for each state over four regimes. Regimes were set as 10 year blocks of time based on the trends in the abundance of the most commonly associated species (Figure 1). Within each regime, only species that were intercepted 100 or more times in a given state (i.e., an average 10 times per year) were included in the association analysis. Maine and

New Hampshire did not have any significant, positive associations for any regime; Connecticut, Delaware, and Maryland had one or more regimes without a significant positive association, but did have at least one regime with a significant positive association (Figure 2 - Figure 17). Given the lack of significant, positive associations and the overall low rate of positive intercepts of bluefish for Maine and New Hampshire, those states were dropped from the CPUE analysis. For the remaining states, a trip was identified as a "bluefish trip" if it caught bluefish or one of the other significant positively associated species during that regime. If no significant positive associations were identified for a state during a regime, directed trips were substituted (i.e., trips that reported targeting or catching bluefish in that state during that regime).

The public dataset that was queried for this analysis includes imputed data for 2020, but those records were excluded from this analysis.

CPUE for both the directed trips subset and the species association trips subset was defined as total catch (number of bluefish harvested and released alive) per trip. CPUE was standardized using a GLM framework. Negative binomial models with and without zero-altered and zero-inflated components were explored using the *glmmTMB* (Brooks et al. 2017) package in R. Factors explored in the standardization included year, mode of fishing (shore, private/rental boat, for-hire), area fished (inshore, state waters, federal waters), wave, state, kind of day (weekday vs. weekend), and avidity (number of days fished in the last year). The natural log of angler-hours (the number of anglers on the trip multiplied by the number of hours reported fished) was used as an effort offset.

An examination of unstandardized CPUE showed different seasonal patterns in catch rates across states, with catch rates increasing in the summer for the northern states and decreasing during the summer for the southern states, reflecting the migratory pattern of bluefish (Figure 18). To account for this, a state-wave interaction term was included in the standardization. Since MRIP does not conduct dockside sampling during Wave 1 and some of the more northern states did not encounter bluefish during Wave 2, those waves were dropped from the analysis for both the guild trips and the directed trips approach. The species associations were rerun using only Waves 3-6 data for the final index.

AIC values and examination of residuals was used to determine the final model for both directed trips and the guild trips. The *DHARMa* package in R (Hartig 2022) was used to examine residual patterns for the fitted models; the *DHARMa* package compares observed residuals to simulated residuals to provide residual plots for negative binomial and other distributions that are more comparable to a traditional lognormal residual plot. Divergence from the simulated residuals can be used to diagnose poor fits for these more complex models.

The final index was calculated as the marginal mean CPUE for each year. The CV was estimated by bootstrapping the index: the trip records for each year were resampled to create a new dataset which was then fit using the final model.

Results
Sub-setting the MRIP intercepts to directed bluefish trips (i.e., trips where the angler reported targeting or catch bluefish) resulted in approximately 282,000 intercepts over forty years. Of those trips, 64% were positive trips (i.e., caught bluefish). Sub-setting the MRIP intercepts to guild trips resulted in approximately 366,000 records over 40 years, of which 49.5% were positive trips.

The final model for both trip subsets was a zero-altered negative binomial model with year, state, wave, state-wave interaction, mode, area fished, kind of day, and avidity as factors. The DHARMa package flagged some of the residuals as deviating significantly from the expected distribution, but this was likely due to the large sample size for both datasets. Visual inspection of the residuals did not reveal major problems (Figure 19 - Figure 34).

Both indices showed similar trends over time, declining from beginning of the time series to the late 1990s, stabilizing through the 2000s and early 2010s before declining again in the most recent few years (Table 1 and Table 2, Figure 35). The guild trips approach showed more contrast than the directed trips index, starting out higher and declining to lower levels than the directed trips index. However, the confidence intervals for both overlapped each other (Figure 36).

Discussion
Both the directed trips and the guild trips methods have drawbacks. The directed trips method relies on anglers reporting their behavior after the trip is completed and can miss zero-catch trips where anglers reported targeting other species or did not have a specific target in mind, but were still fishing in areas using methods that could have caught bluefish if they were available. The guild trips method relies on species associations and catch composition to identify trips: because striped bass and bluefish are often caught together, a trip that caught striped bass likely had a high probability of catch bluefish if bluefish were available, so a trip that caught striped bass but not bluefish is a legitimate bluefish trip with zero catch. On the other hand, Atlantic cod is negatively associated with bluefish, so a trip that caught Atlantic cod but not bluefish would not be expected to catch bluefish if bluefish were available, so that trip can be excluded from the analysis. The weakness of the guild trips approach is that it can be influenced by trends in the abundance of the associated species: if striped bass are declining, then the number of trips that catch striped bass will also decline, reducing the number of potential zero trips in the dataset. The regime approach to identifying significant species can help here, but does not fully resolve the problem.

After weighing the strengths and weaknesses of each analysis, the WG decided to use the guild trips index for the base run of the model, with the directed trips index as a sensitivity run.

The index-at-age information for the MRIP CPUE index is derived from the recreational harvest and release catch-at-age information (see Working Paper 8 Wood 2022a for more details on how the catch-at-age information was derived). The harvest-at-age matrix is combined with the total release-at-age matrix, as the MRIP CPUE includes both landed fish and fish released alive;

the release-at-age matrix is not decremented to account for release mortality the way it is for the recreational fleet.

Literature Cited

Brooks, M. E., K. Kristensen, K. J. van Benthem, A. Magnusson, C. W. Berg, A. Nielsen, H. J. Skaug, M. Maechler, and B. M. Bolker. 2017. glmmTMB Balances Speed and Flexibility Among Packages for Zero-inflated Generalized Linear Mixed Modeling. The R Journal 9(2):378–400.

Chung, N. C., B. Miasojedow, M. Startek, and A. Gambin. 2018. jaccard: Test Similarity Between Binary Data using Jaccard/Tanimoto Coefficients.

Hartig, F. 2022. DHARMa: Residual Diagnostics for Hierarchical (Multi-Level / Mixed) Regression Models.

Northeast Fisheries Science Center. 2015. 60th Northeast Regional Stock Assessment Workshop (60th SAW) assessment report. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, MA.

Tables

Table 1: MRIP CPUE calculated using the guild trips subset of data.

Year	CPUE	CV
1982	0.35	0.17
1983	0.28	0.17
1984	0.31	0.17
1985	0.38	0.17
1986	0.36	0.17
1987	0.33	0.16
1988	0.16	0.17
1989	0.30	0.17
1990	0.25	0.16
1991	0.21	0.16
1992	0.16	0.16
1993	0.12	0.16
1994	0.12	0.17
1995	0.10	0.17
1996	0.09	0.17
1997	0.12	0.17
1998	0.09	0.17
1999	0.14	0.17
2000	0.12	0.17
2001	0.18	0.16
2002	0.11	0.17
2003	0.12	0.17
2004	0.13	0.17
2005	0.13	0.16
2006	0.13	0.16
2007	0.14	0.17
2008	0.14	0.16
2009	0.12	0.17
2010	0.15	0.16
2011	0.15	0.16
2012	0.14	0.17
2013	0.15	0.17
2014	0.16	0.16
2015	0.14	0.17
2016	0.17	0.17
2017	0.12	0.17
2018	0.12	0.16
2019	0.12	0.16
2020	0.08	0.16
2021	0.07	0.17

Table 2: MRIP CPUE calculated using the directed trips subset of data.

Year	CPUE	CV
1982	0.25	0.18
1983	0.20	0.17
1984	0.23	0.18
1985	0.27	0.17
1986	0.29	0.17
1987	0.30	0.17
1988	0.15	0.18
1989	0.22	0.17
1990	0.19	0.17
1991	0.18	0.17
1992	0.13	0.17
1993	0.11	0.17
1994	0.13	0.17
1995	0.11	0.17
1996	0.12	0.17
1997	0.15	0.17
1998	0.12	0.17
1999	0.19	0.17
2000	0.16	0.17
2001	0.21	0.17
2002	0.16	0.17
2003	0.16	0.17
2004	0.18	0.17
2005	0.18	0.17
2006	0.17	0.17
2007	0.18	0.17
2008	0.17	0.17
2009	0.15	0.17
2010	0.18	0.17
2011	0.19	0.17
2012	0.18	0.16
2013	0.18	0.17
2014	0.19	0.17
2015	0.16	0.17
2016	0.20	0.17
2017	0.16	0.17
2018	0.17	0.17
2019	0.16	0.17
2020	0.14	0.15
2021	0.11	0.17

Figures

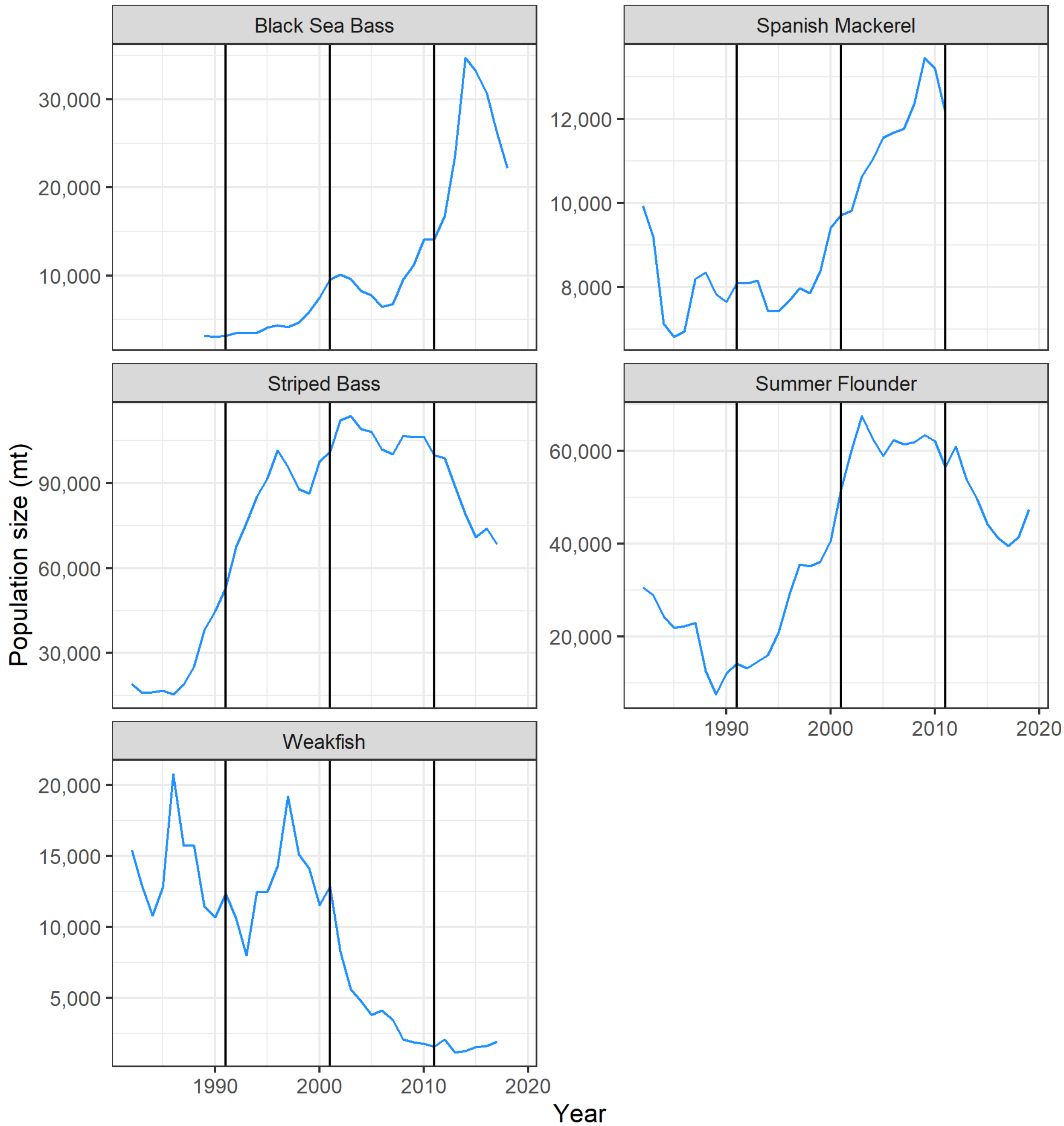

Figure 1: Trends in population sizes for most common associated species of bluefish. Vertical black bars indicate the break points for the regimes in the species association analysis.

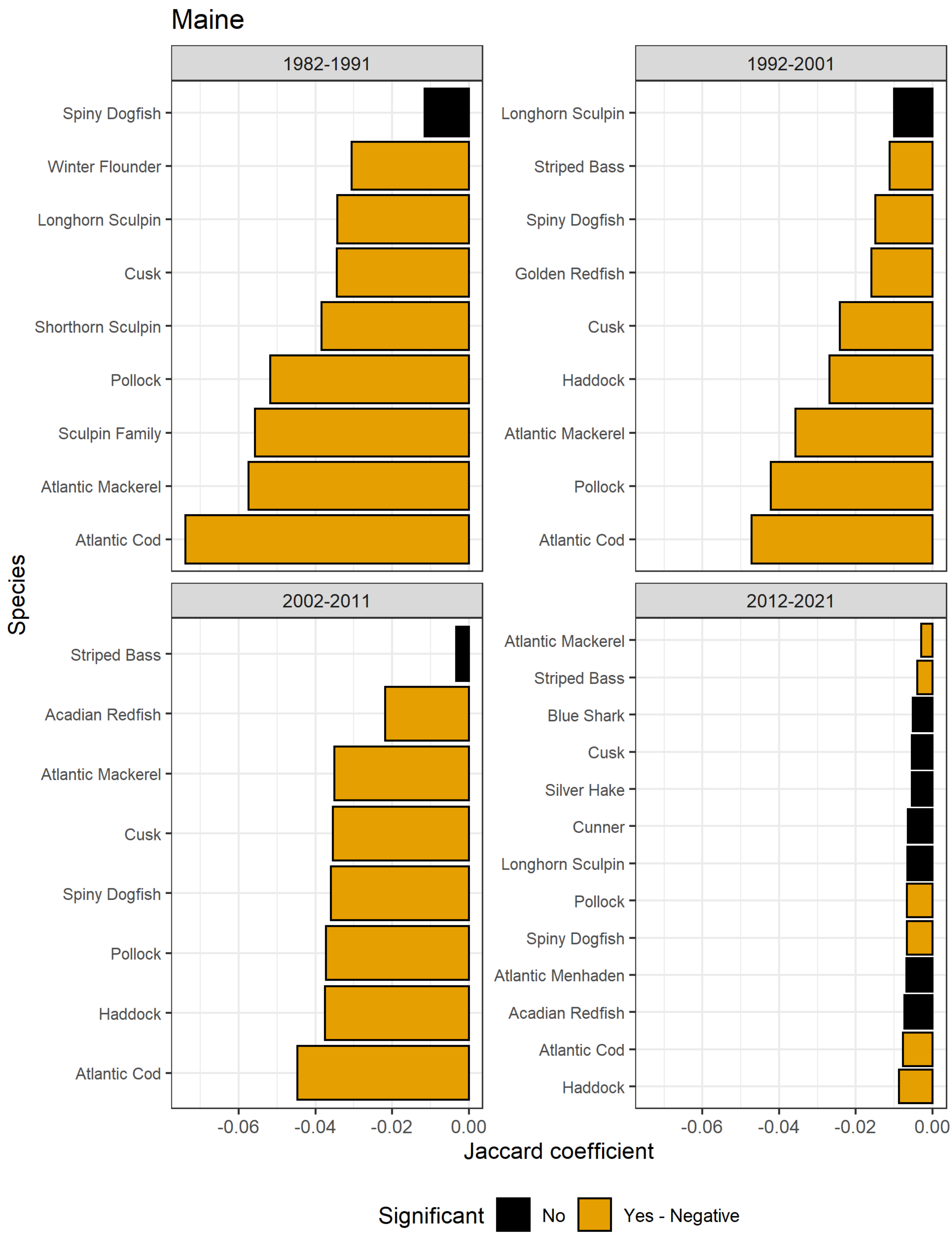

Figure 2: Species associations by regime for Maine.

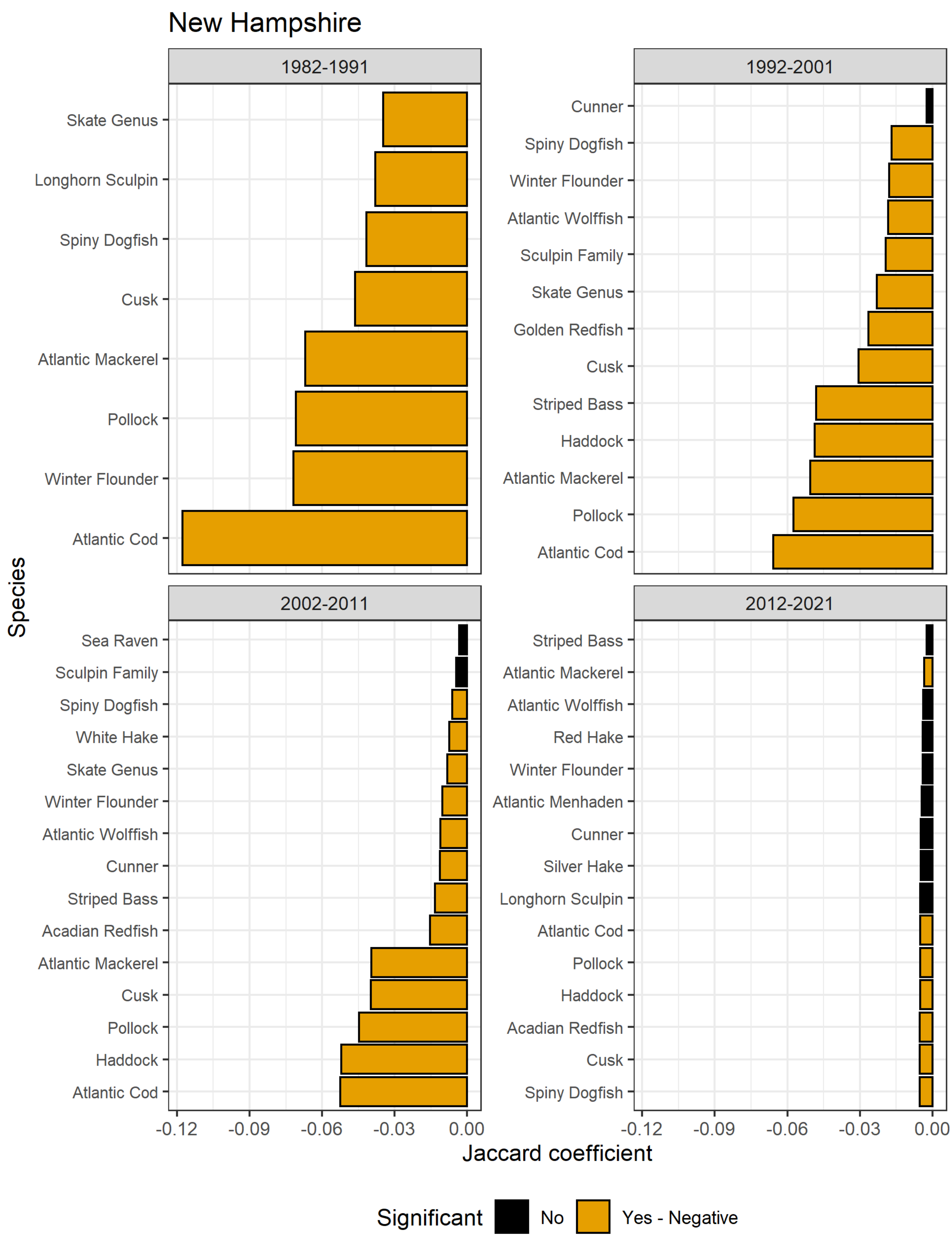

Figure 3: Species associations by regime for New Hampshire.

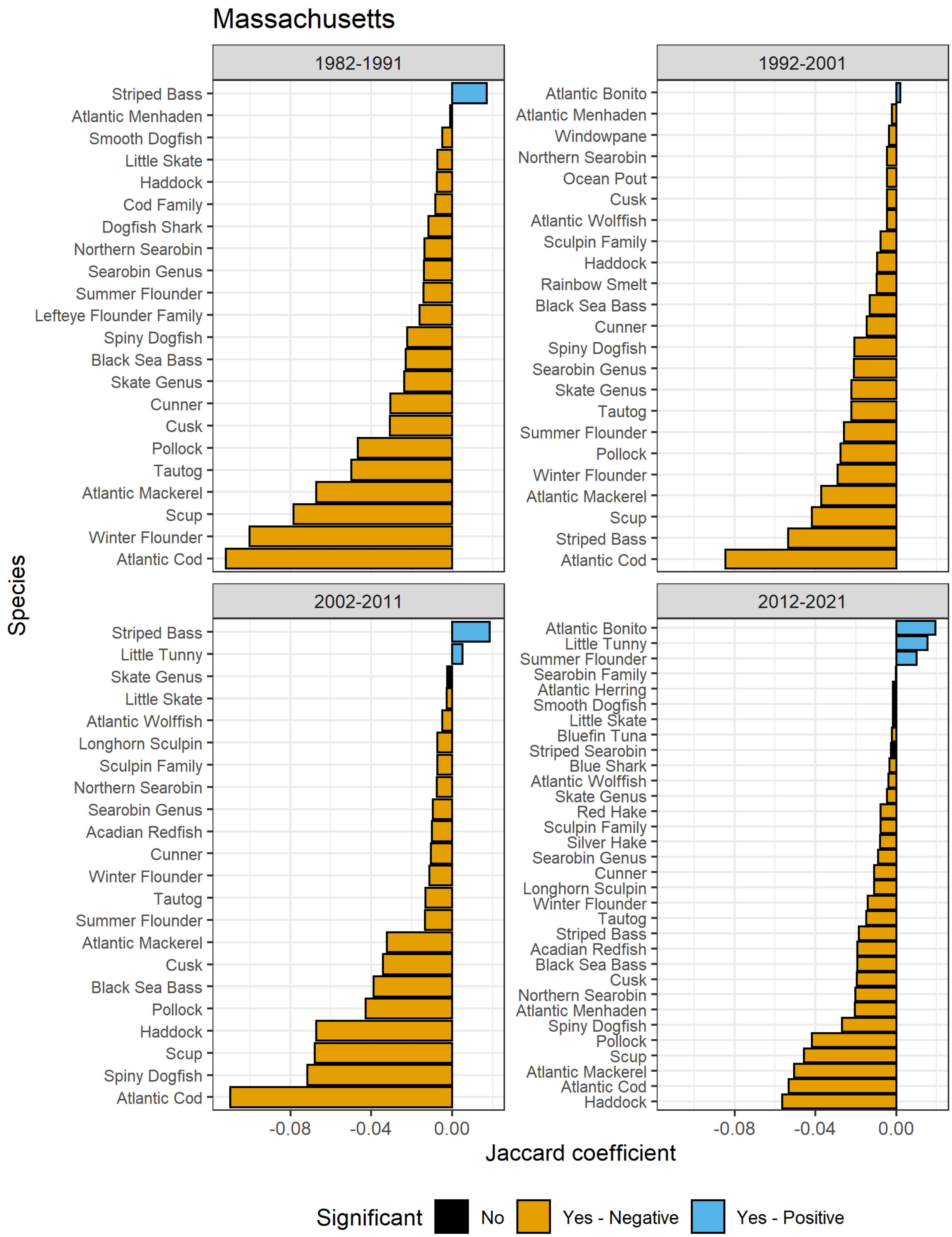

Figure 4: Species associations by regime for Massachusetts.

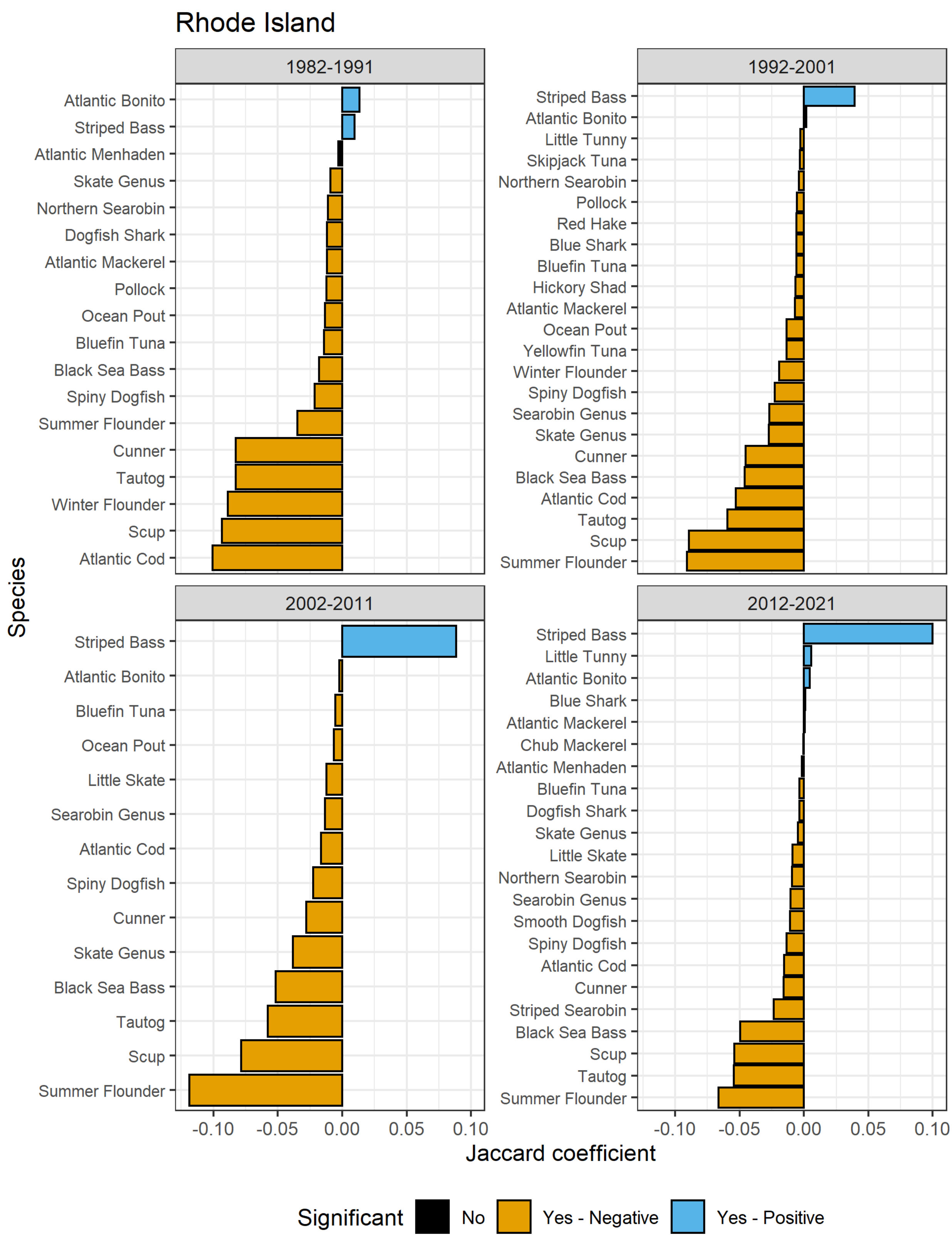

Figure 5: Species associations by regime for Rhode Island.

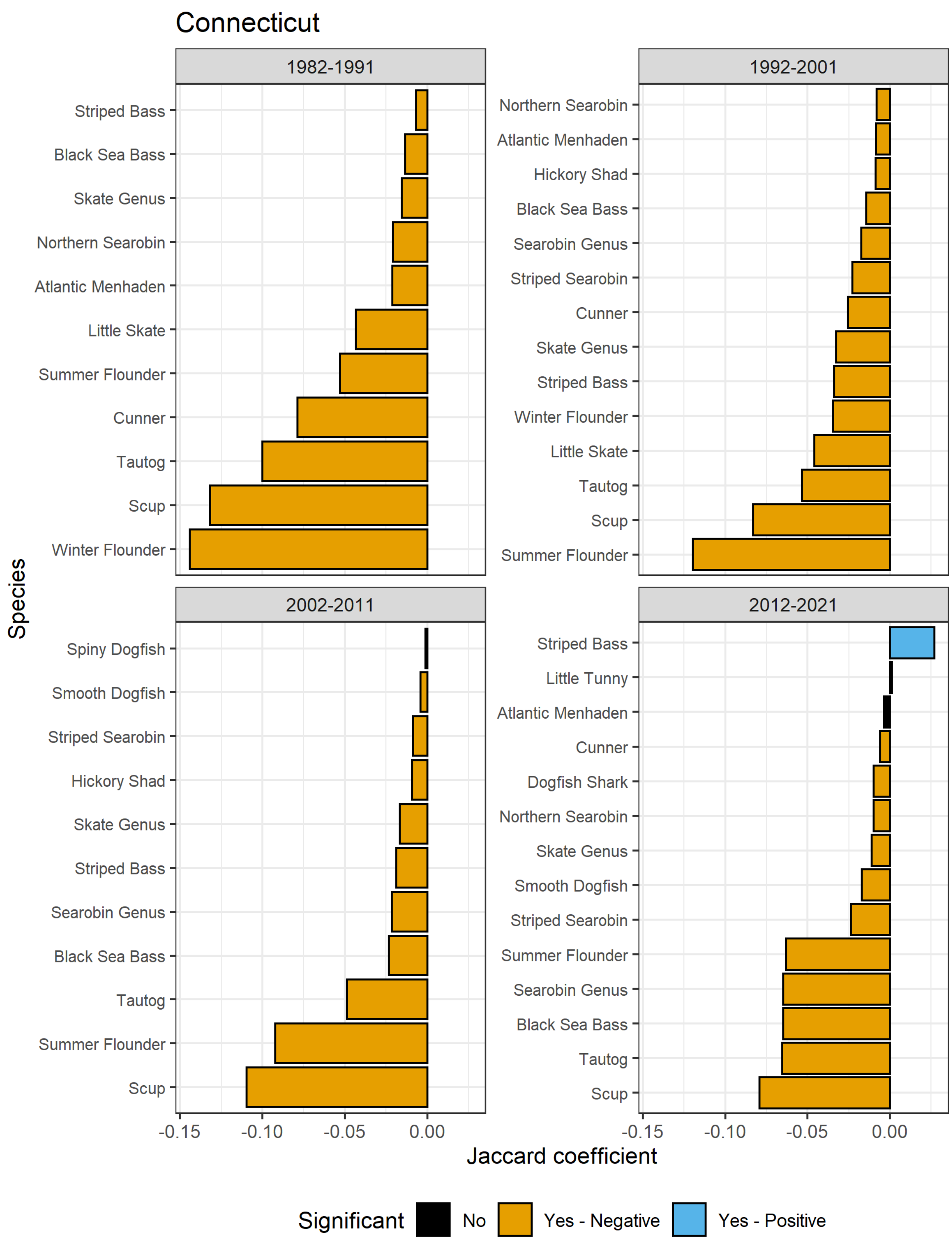

Figure 6: Species associations by regime for Connecticut.

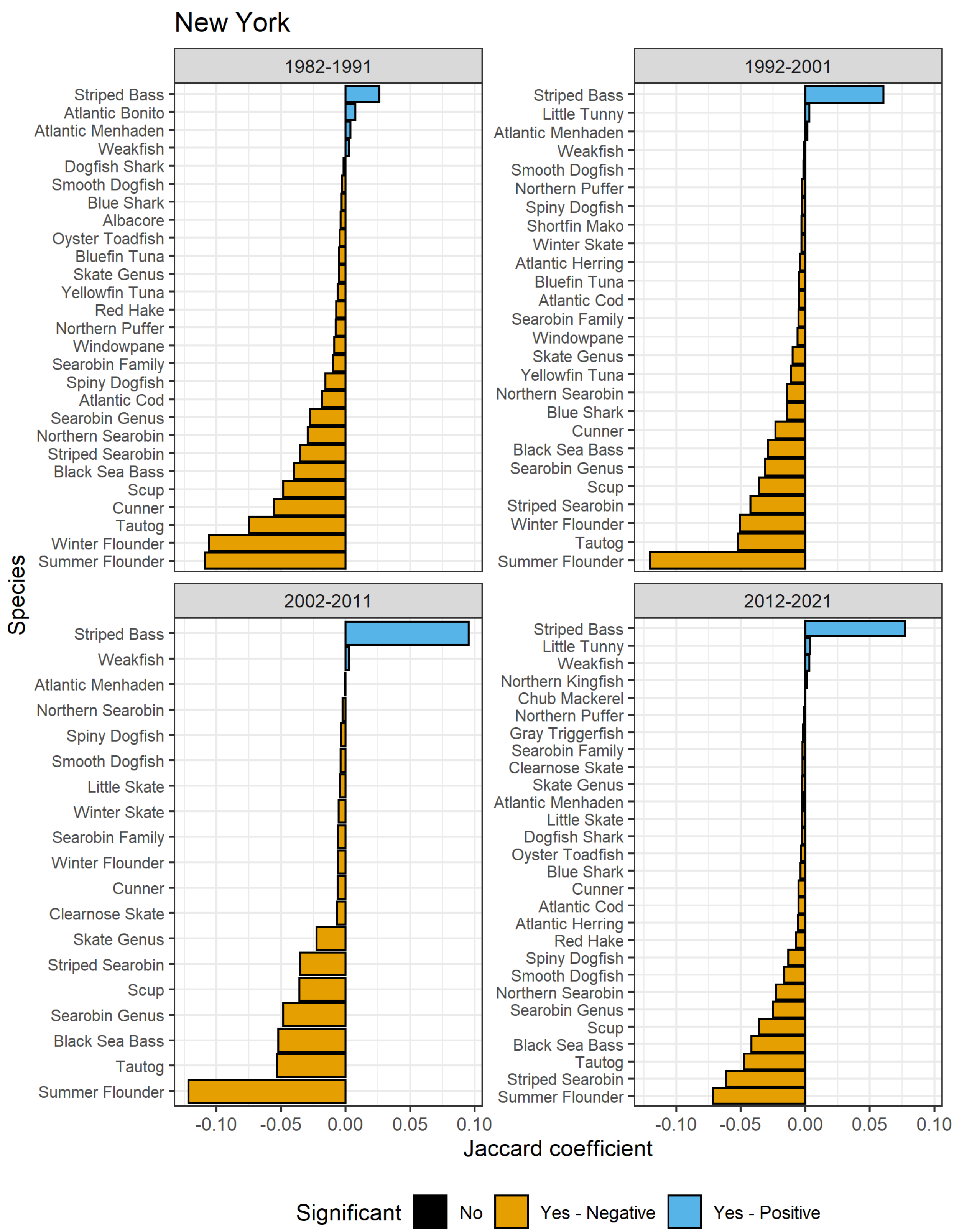

Figure 7: Species associations by regime for New York.

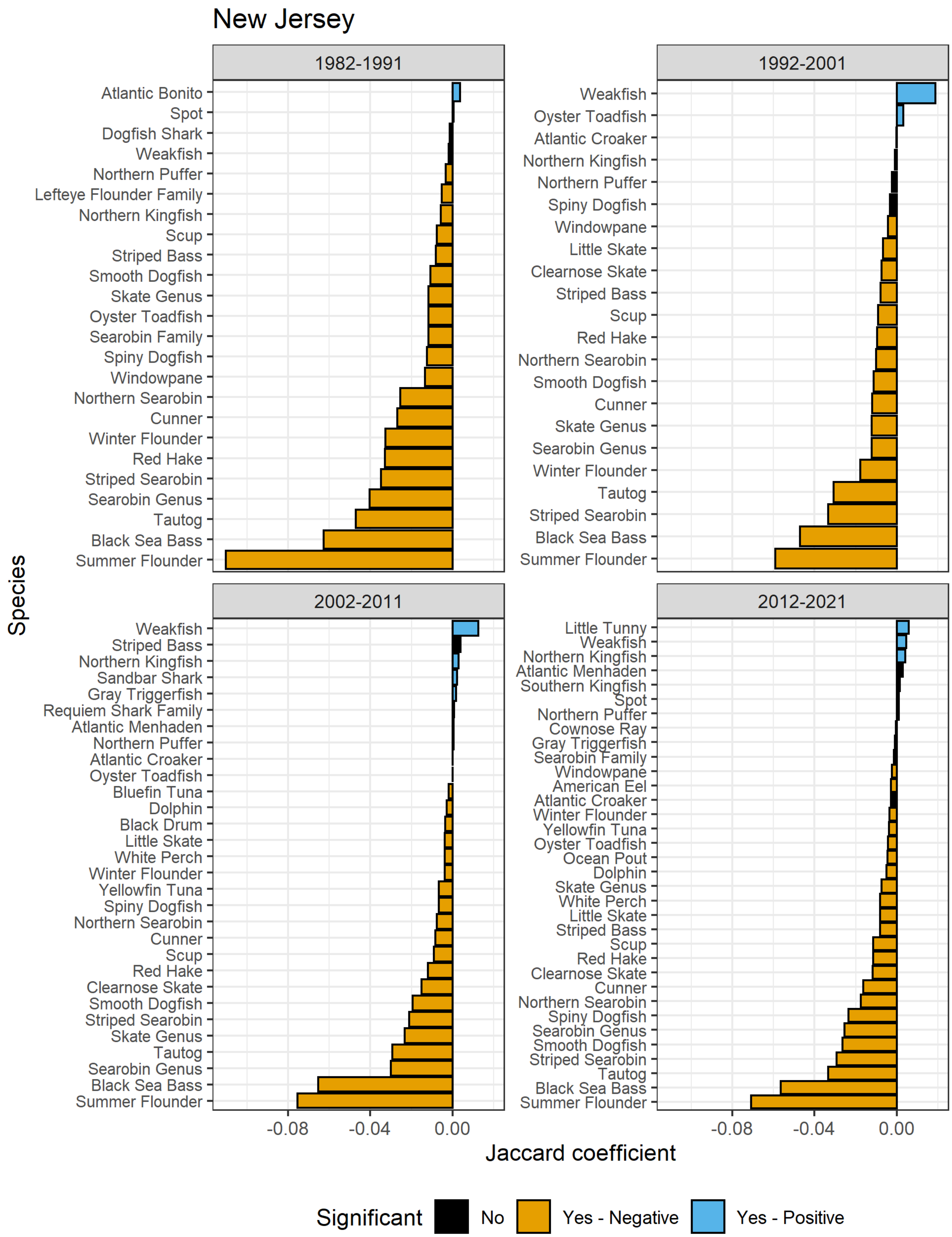

Figure 8: Species associations by regime for New Jersey.

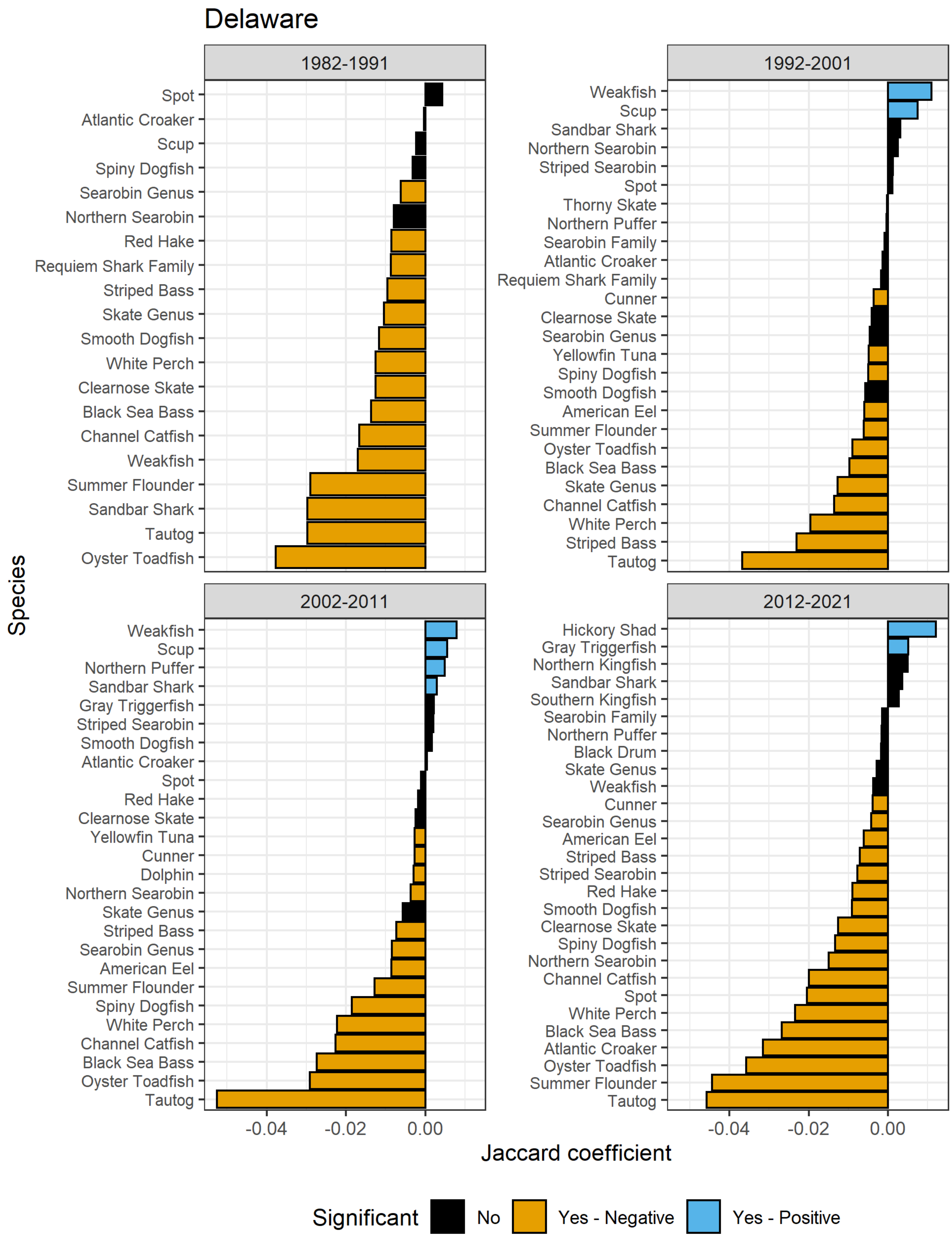

Figure 9: Species associations by regime for Delaware.

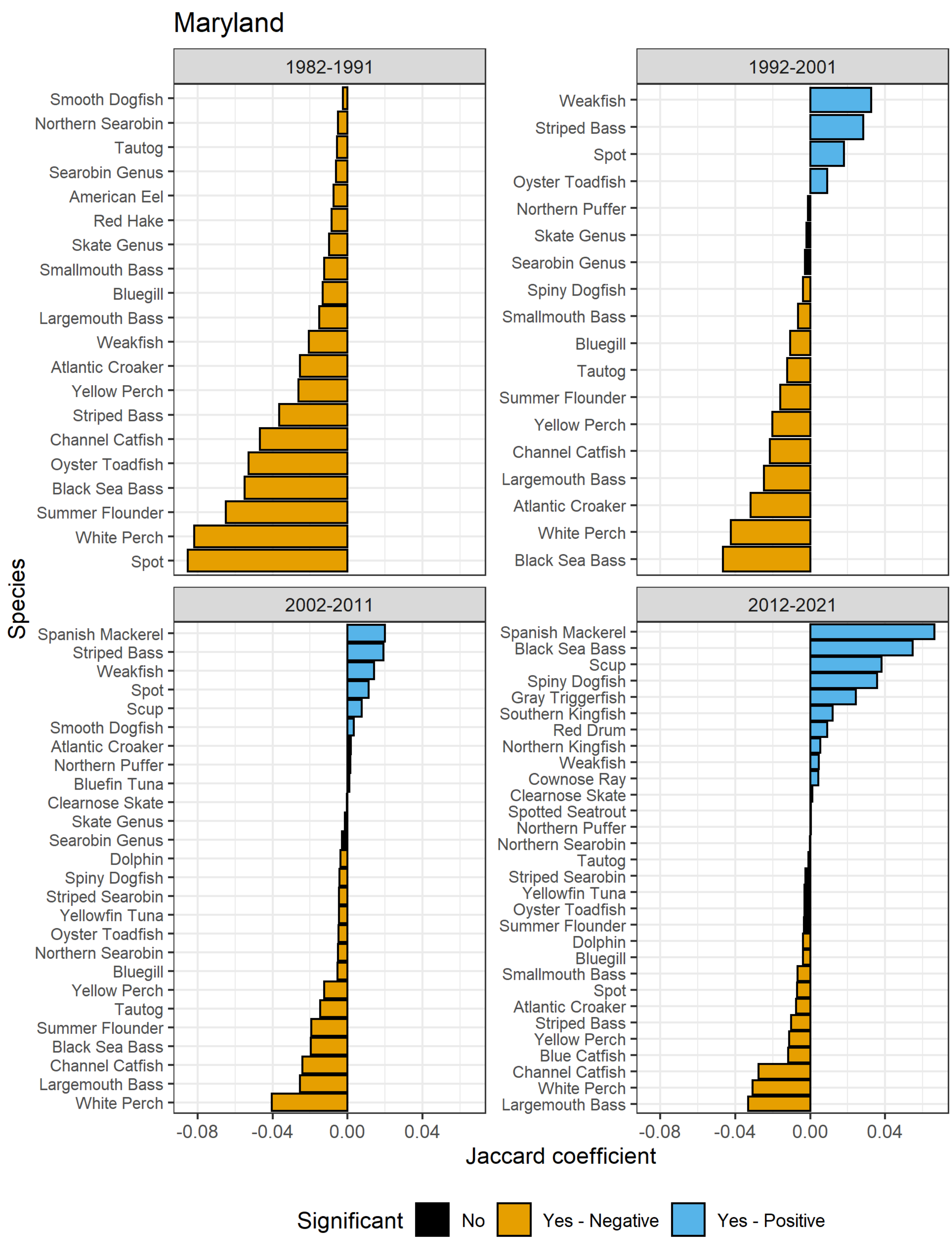

Figure 10: Species associations by regime for Maryland.

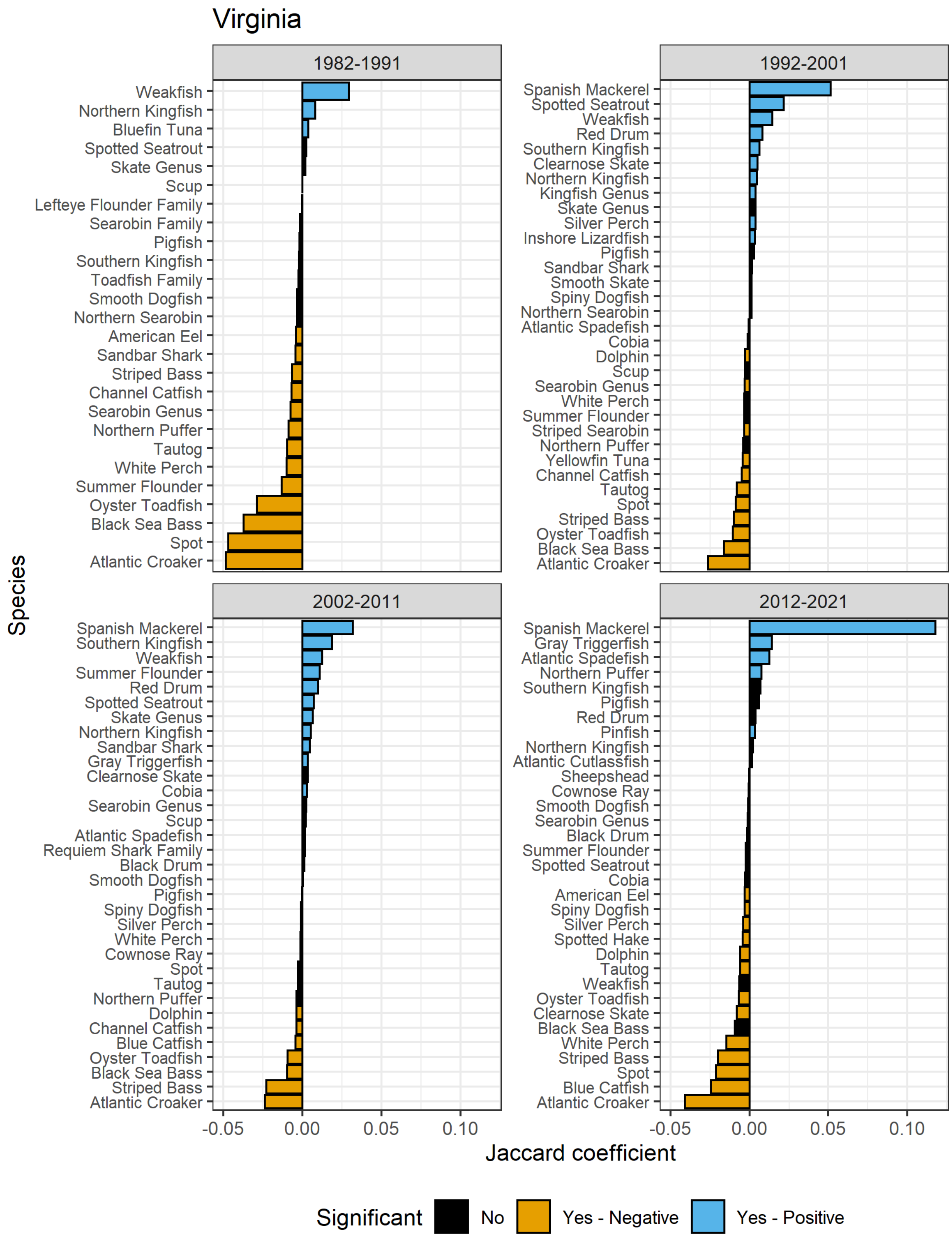

Figure 11: Species associations by regime for Virginia.

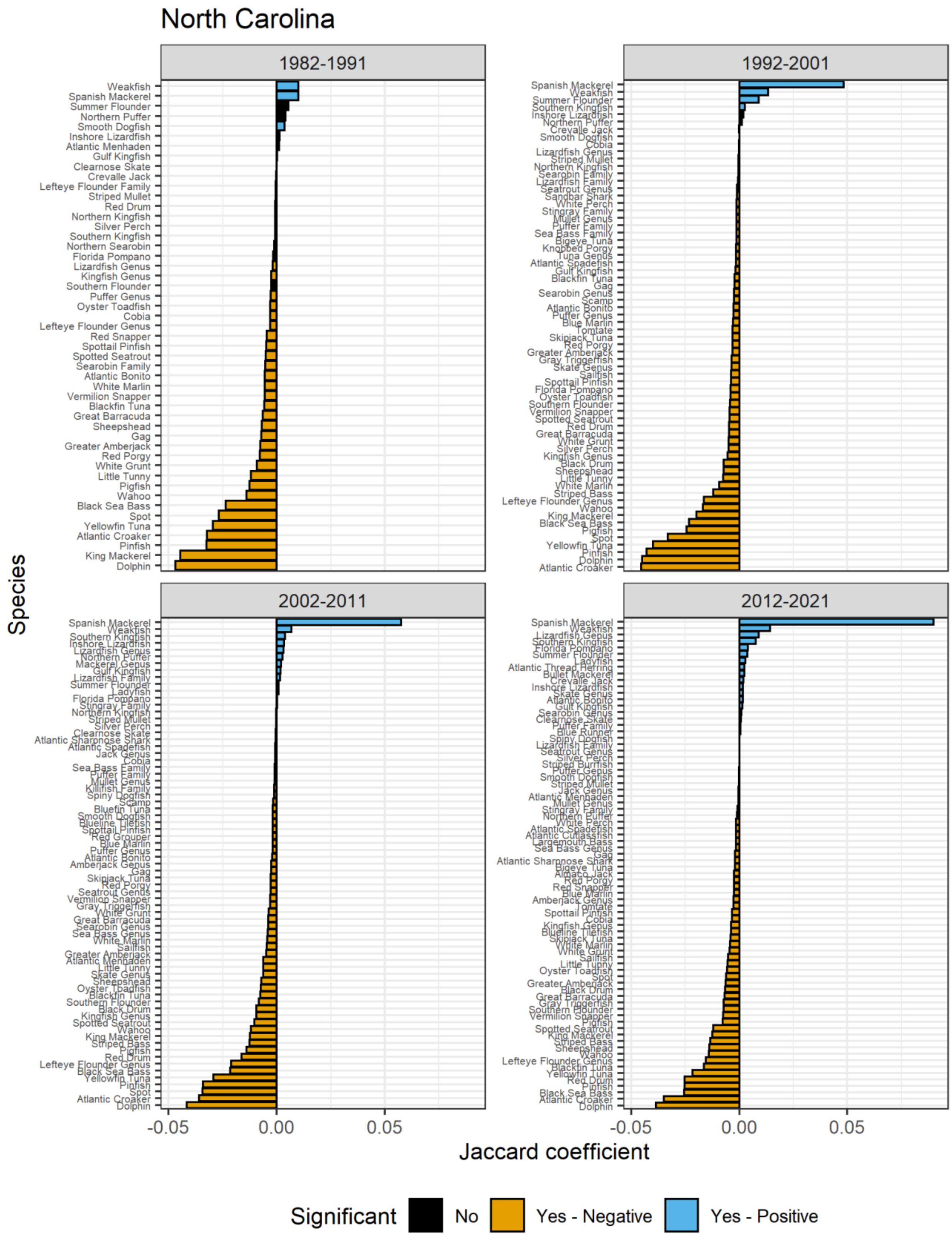

Figure 12: Species associations by regime for North Carolina.

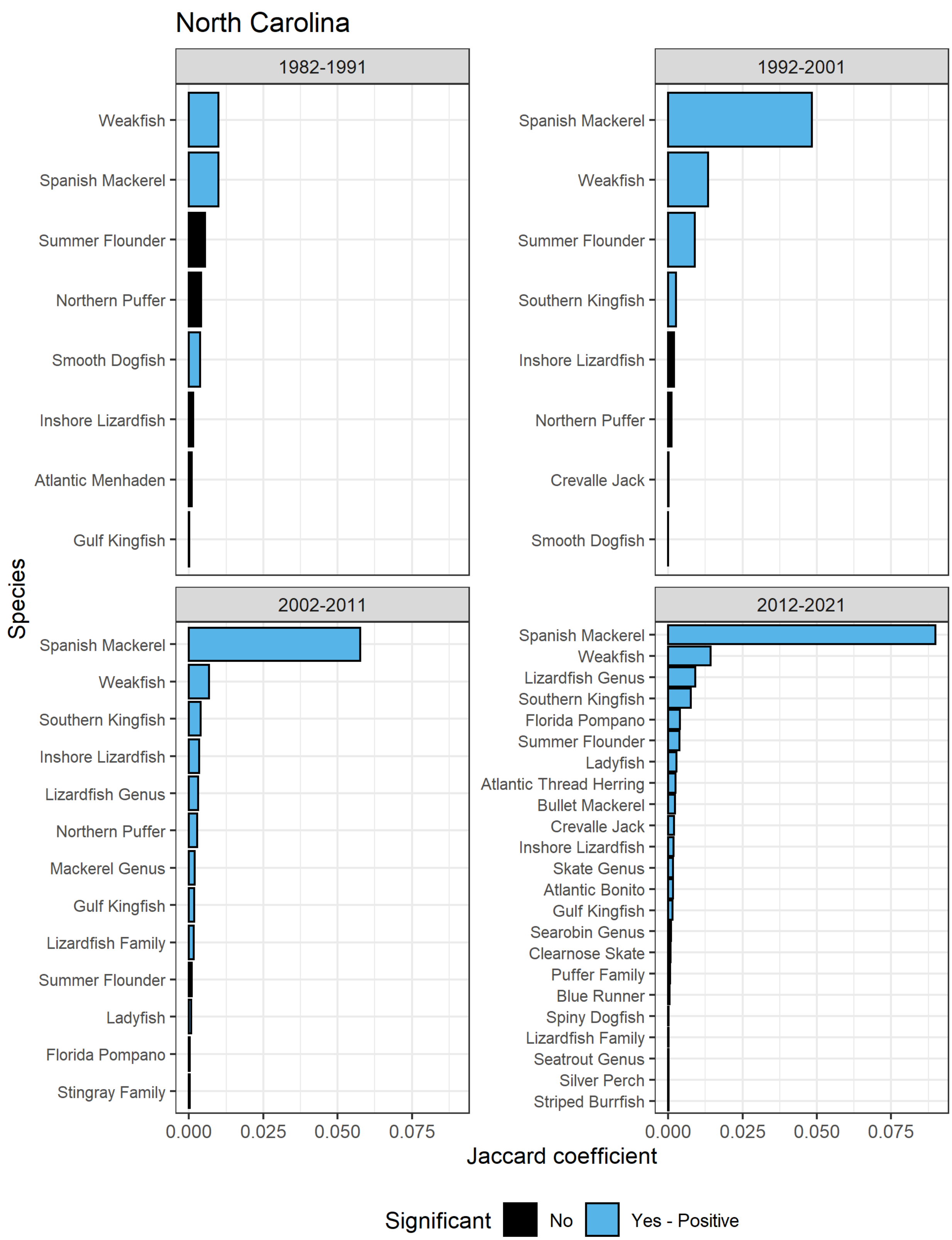

Figure 13: Species associations by regime for North Carolina; positive associations only.

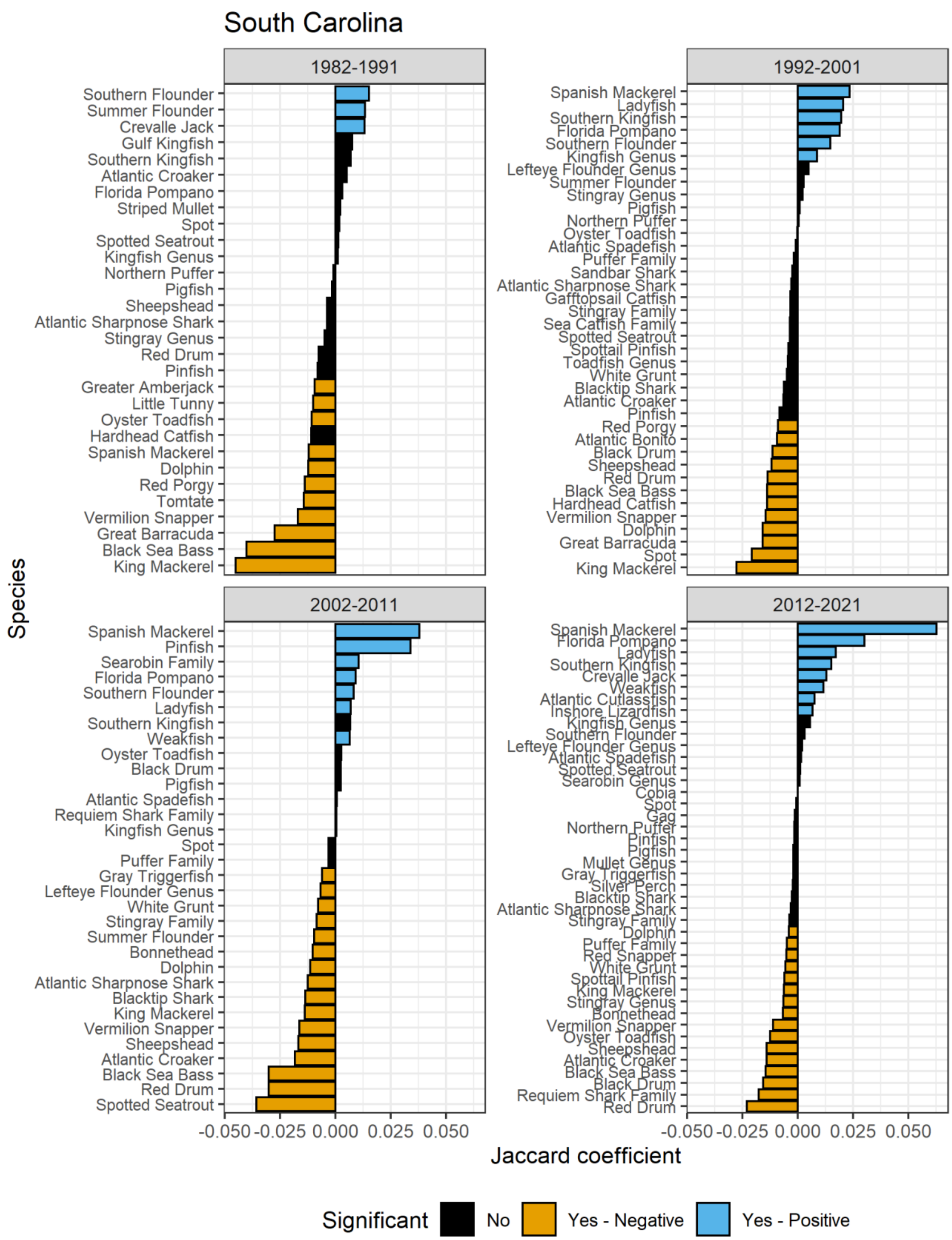

Figure 14: Species associations by regime for South Carolina.

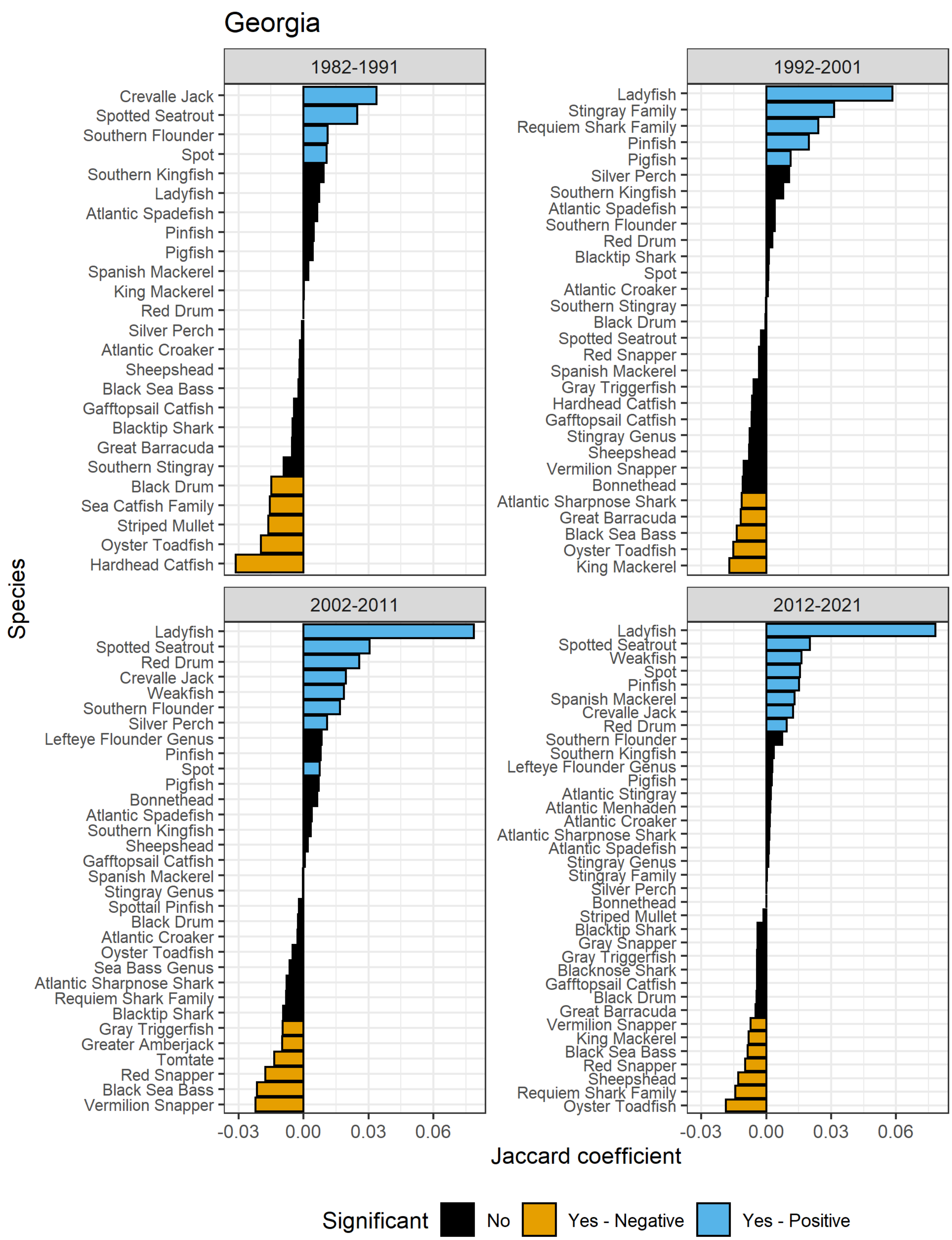

Figure 15: Species associations by regime for Georgia.

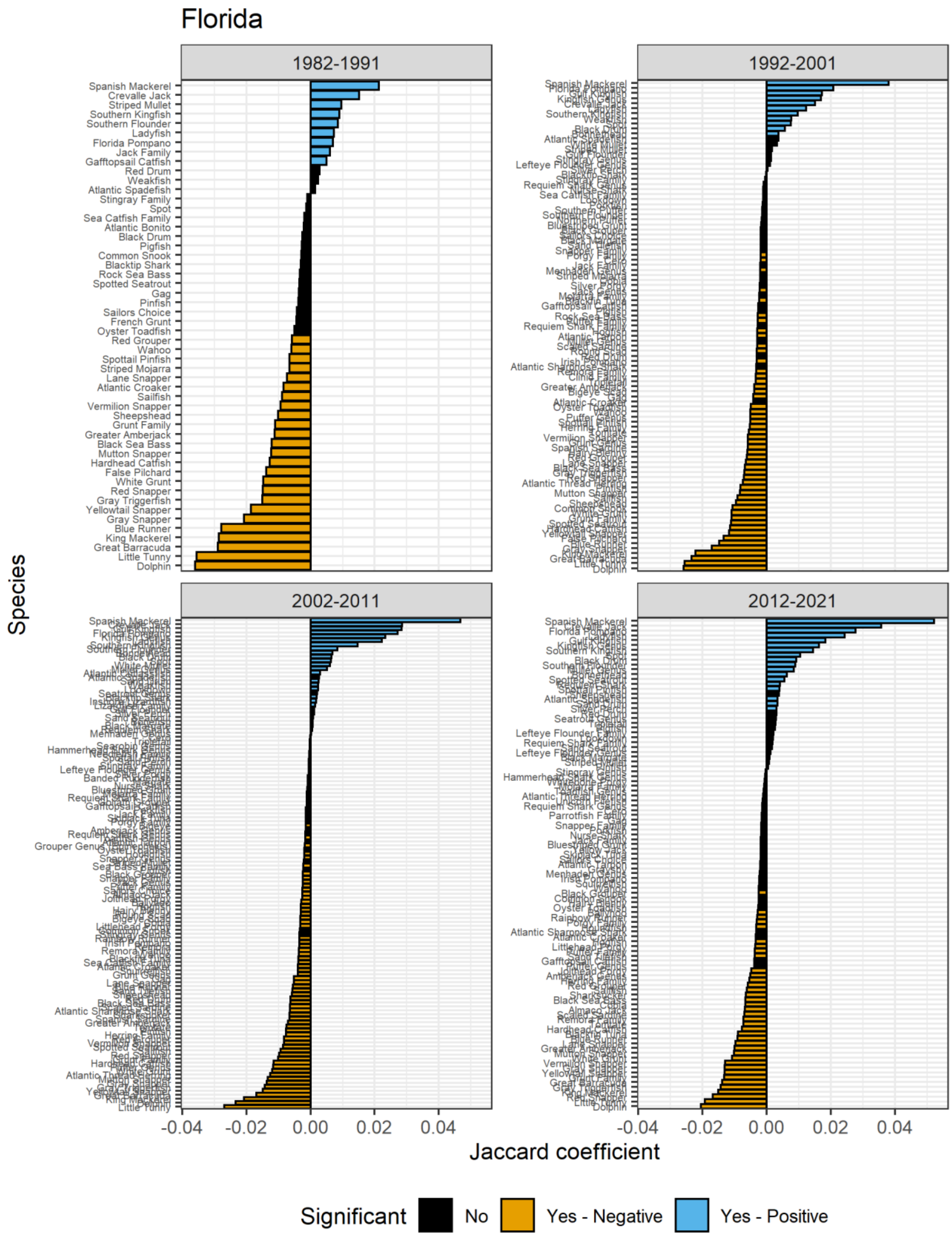

Figure 16: Species associations by regime for Florida.

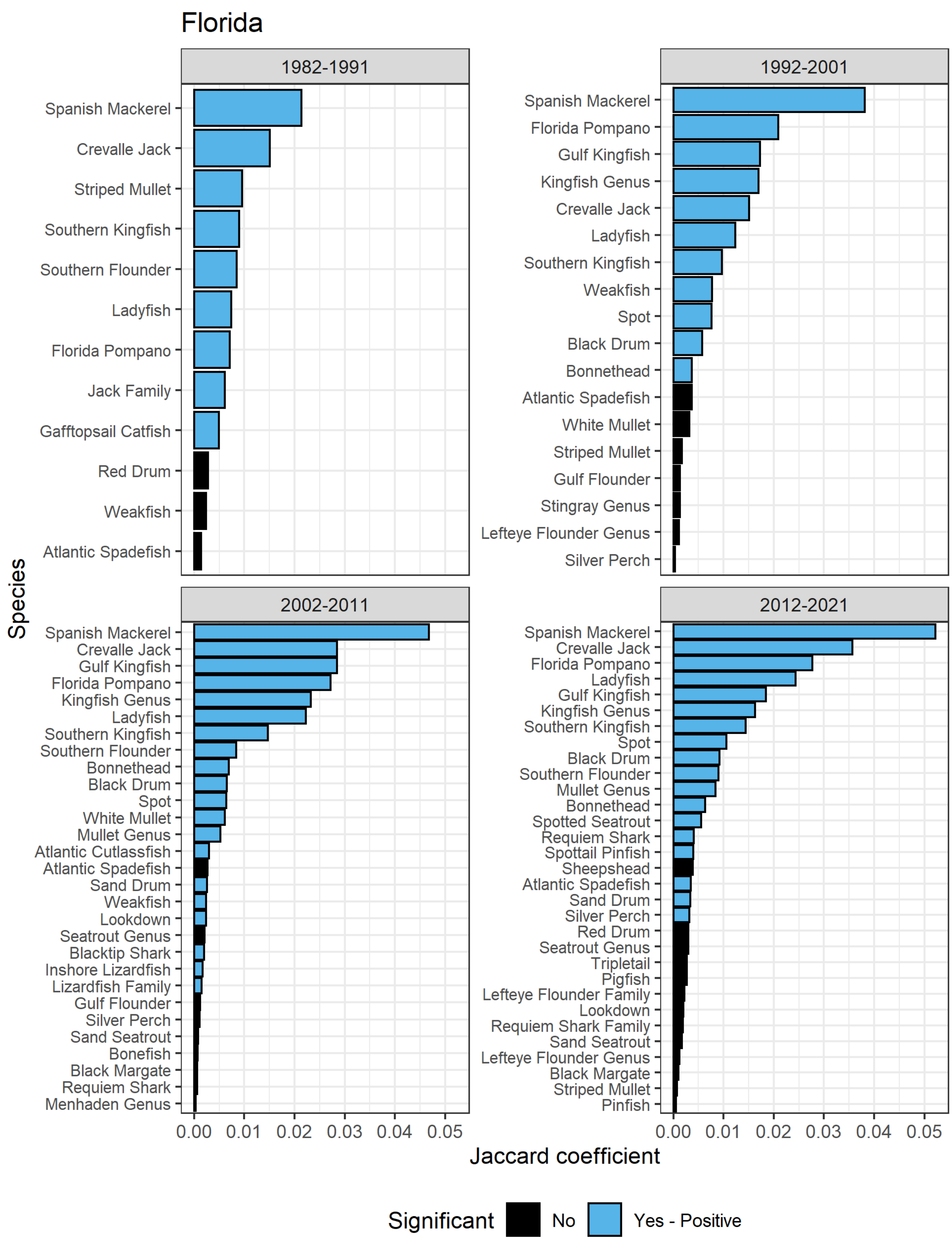

Figure 17: Species associations by regime for Florida; positive associations only.

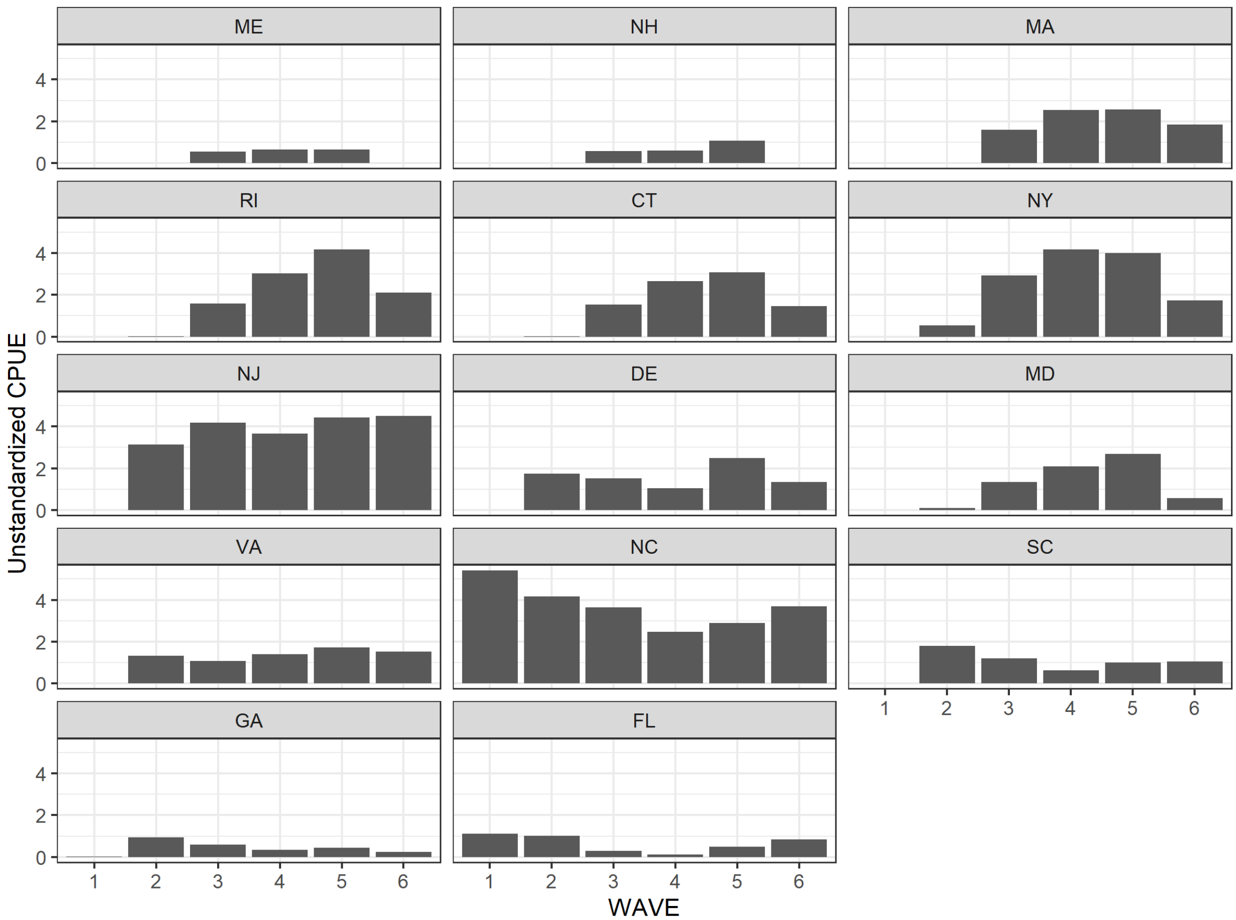

Figure 18: Unstandardized CPUE by state and wave for the guild trips subset of data.

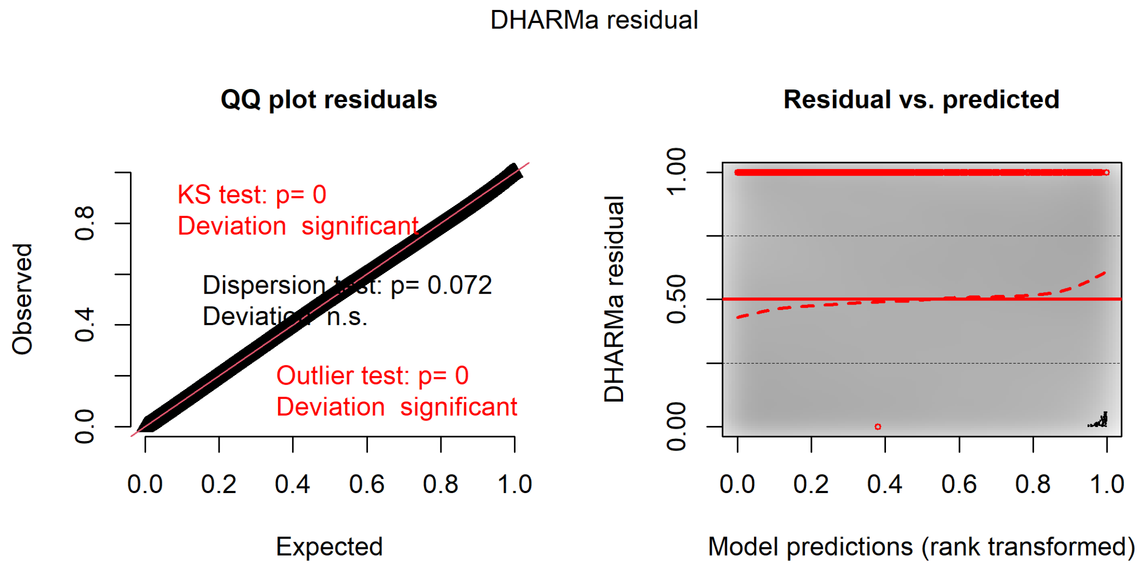

Figure 19: Simulated residuals for the directed trips MRIP index.

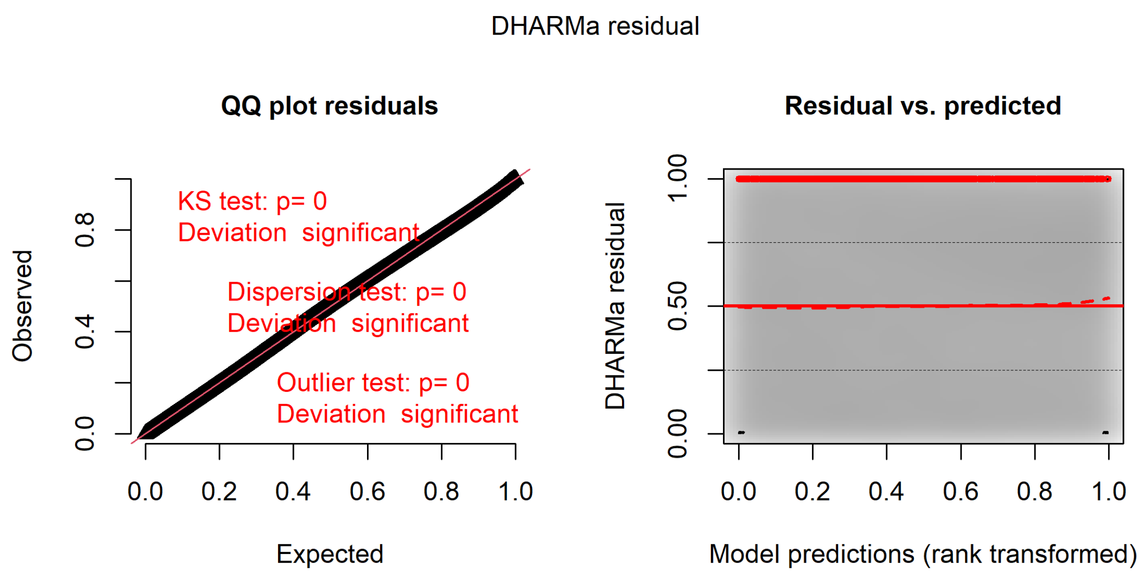

Figure 20: Simulated residual plots for the guild trips MRIP index.

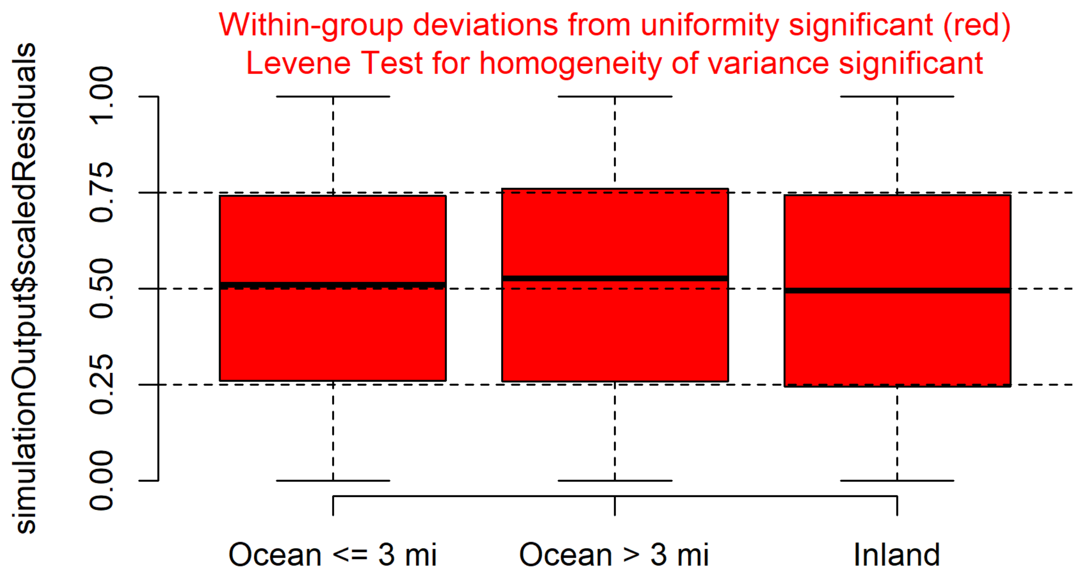

Figure 21: Simulated residuals by area fished for the directed trips MRIP index.

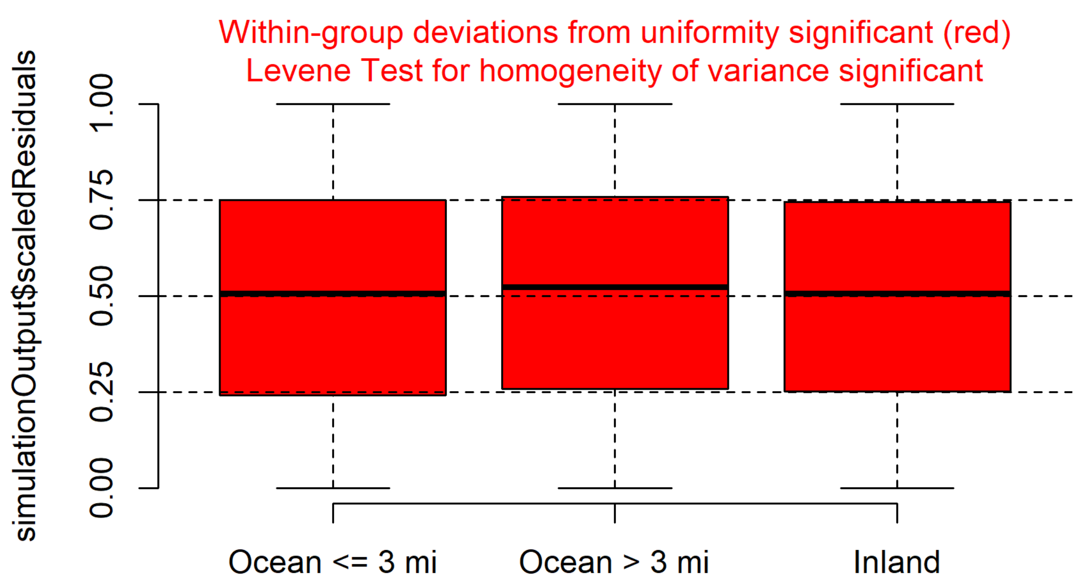

Figure 22: Simulated residuals by area fished for the guild trips MRIP index.

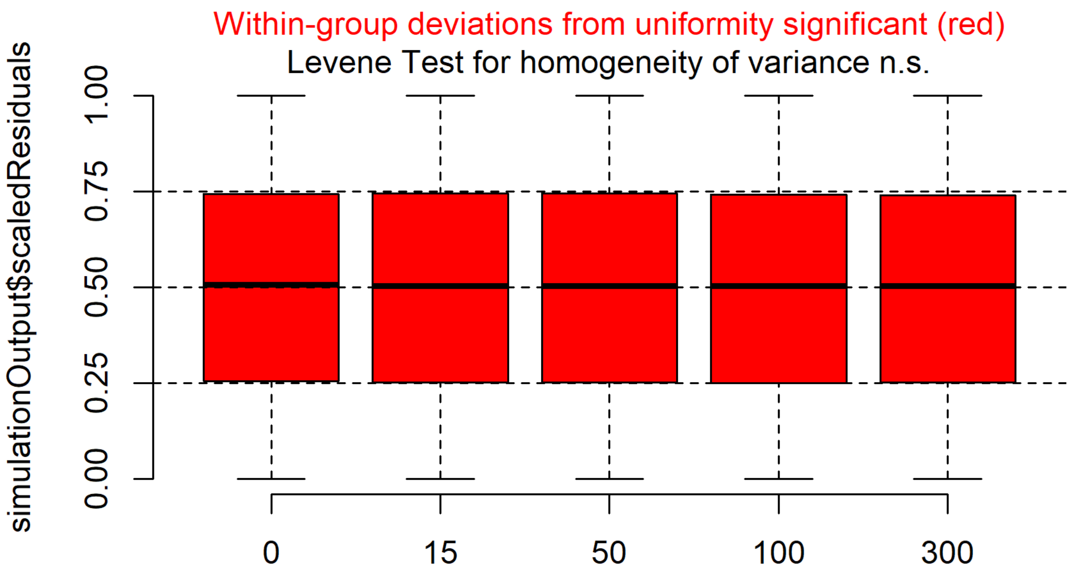

Figure 23: Simulated residuals by avidity category (days fished in the previous 12 months) for the directed trips MRIP index.

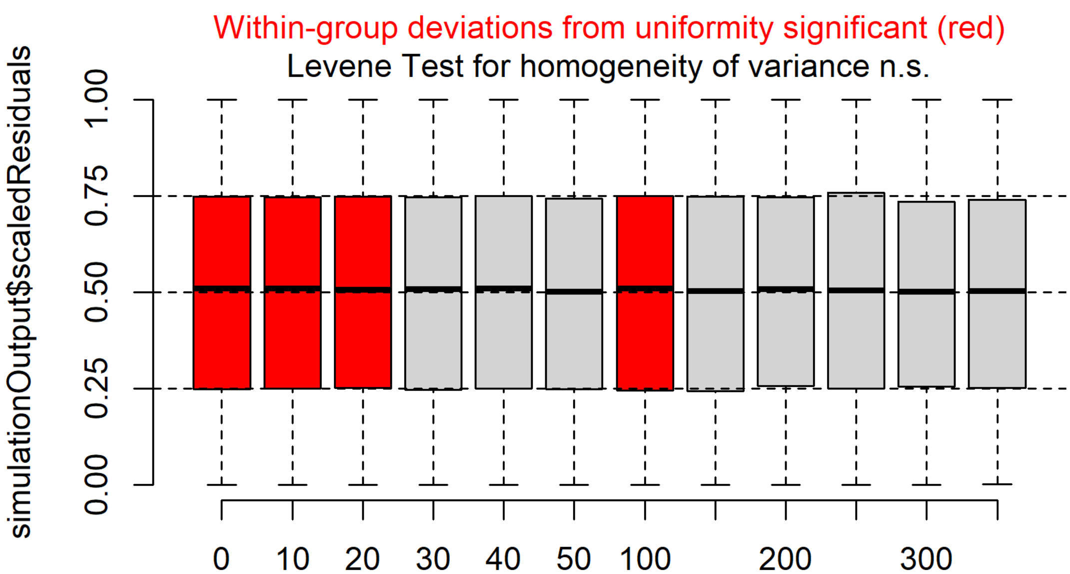

Figure 24: Simulated residuals by avidity category (days fished in the previous 12 months) for the guild trips MRIP index.

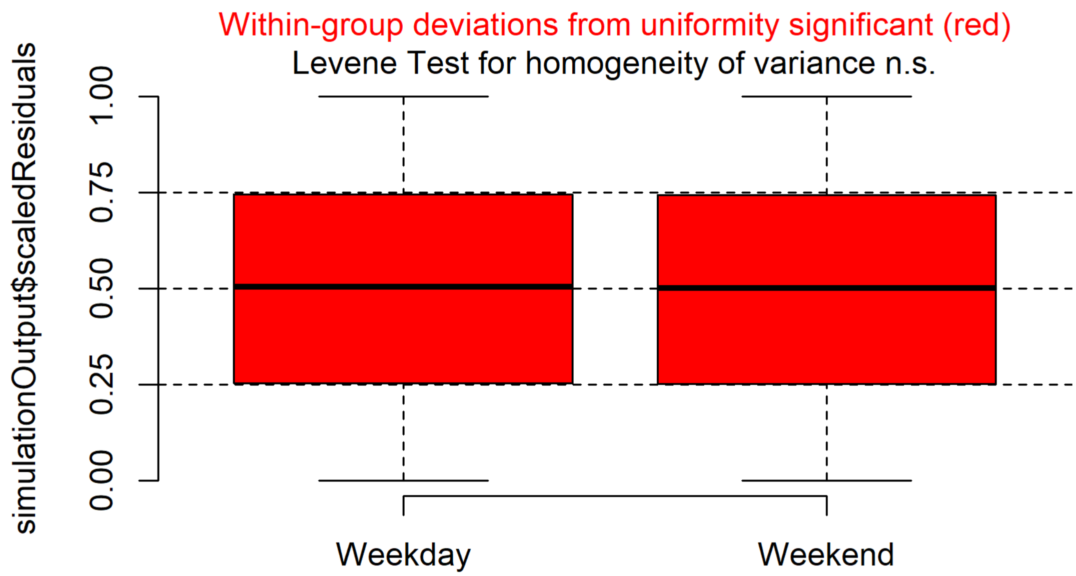

Figure 25: Simulated residuals by kind of day for the directed trips MRIP index.

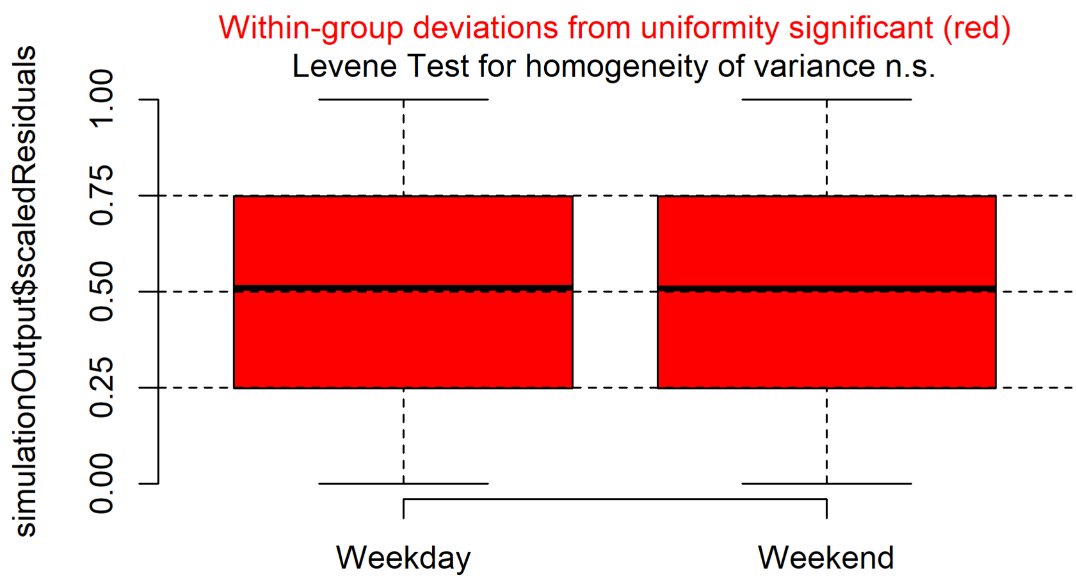

Figure 26: Simulated residuals by kind of day for the guild trips MRIP index.

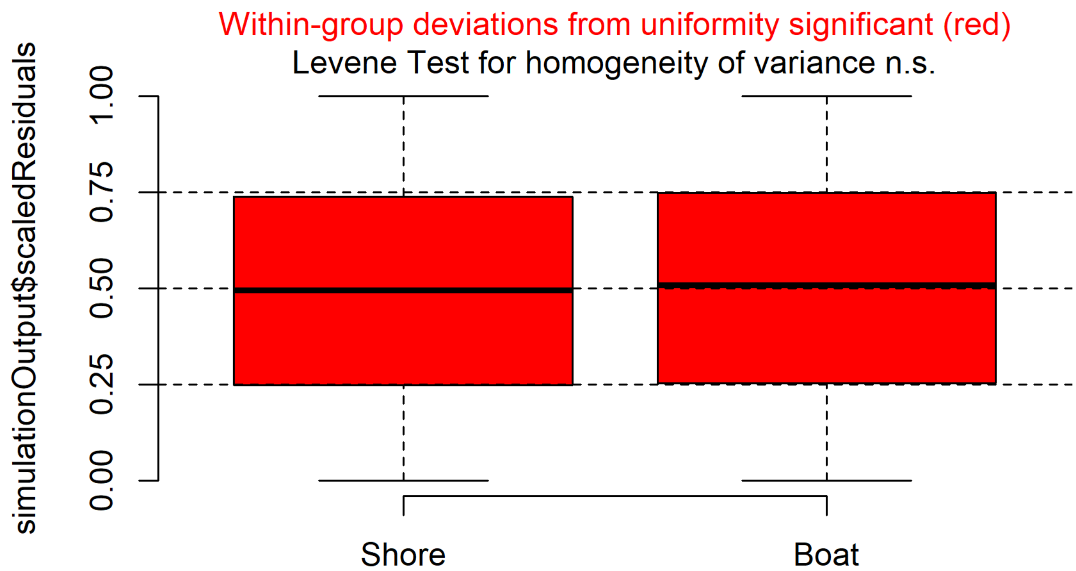

Figure 27: Simulated residuals by mode for the directed trips MRIP index.

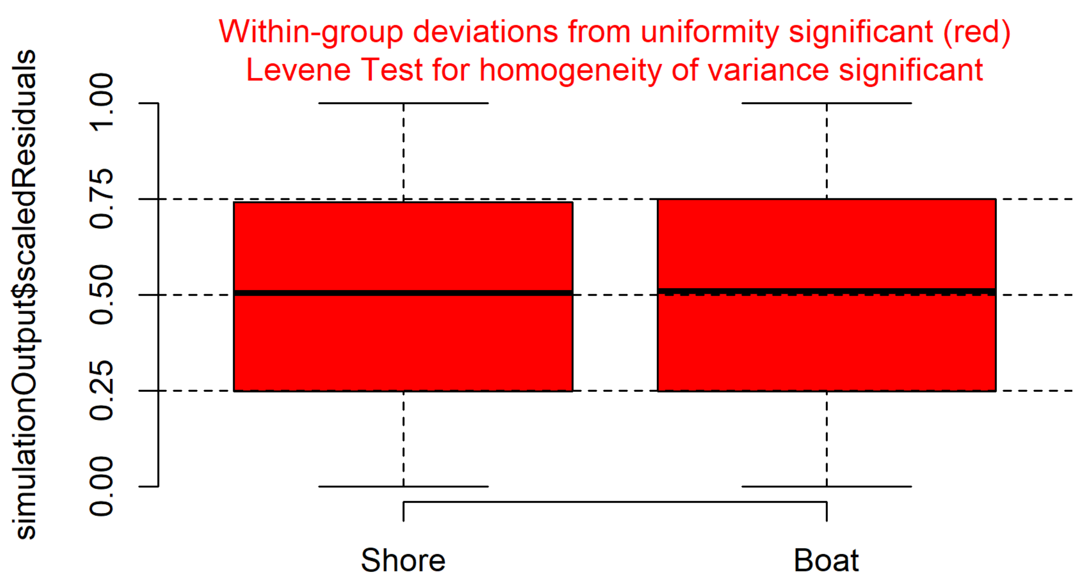

Figure 28: Simulated residuals by mode of fishing for the guild trips MRIP index.

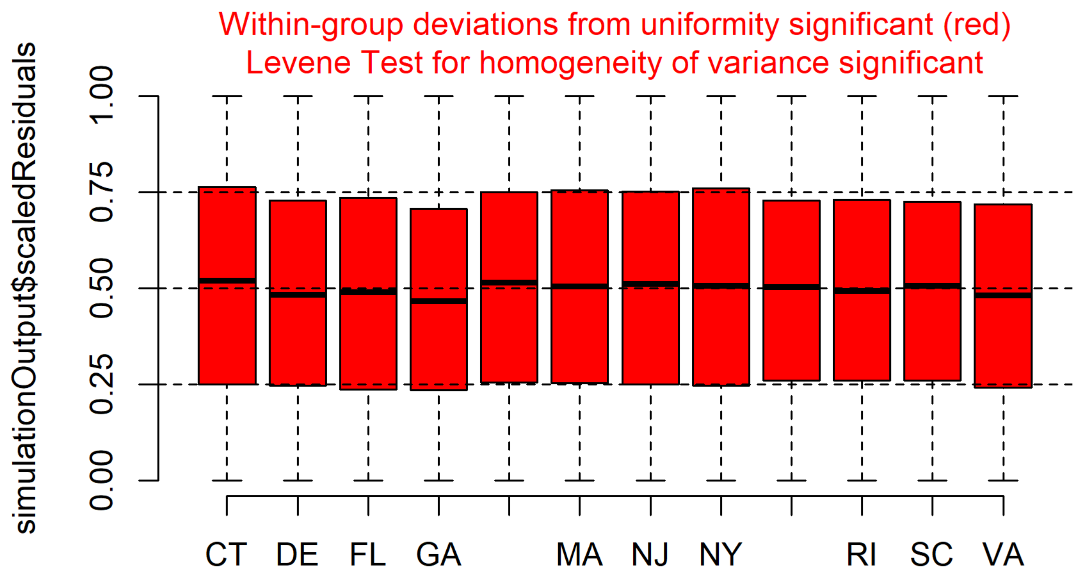

Figure 29: Simulated residuals by state for the directed trips MRIP index.

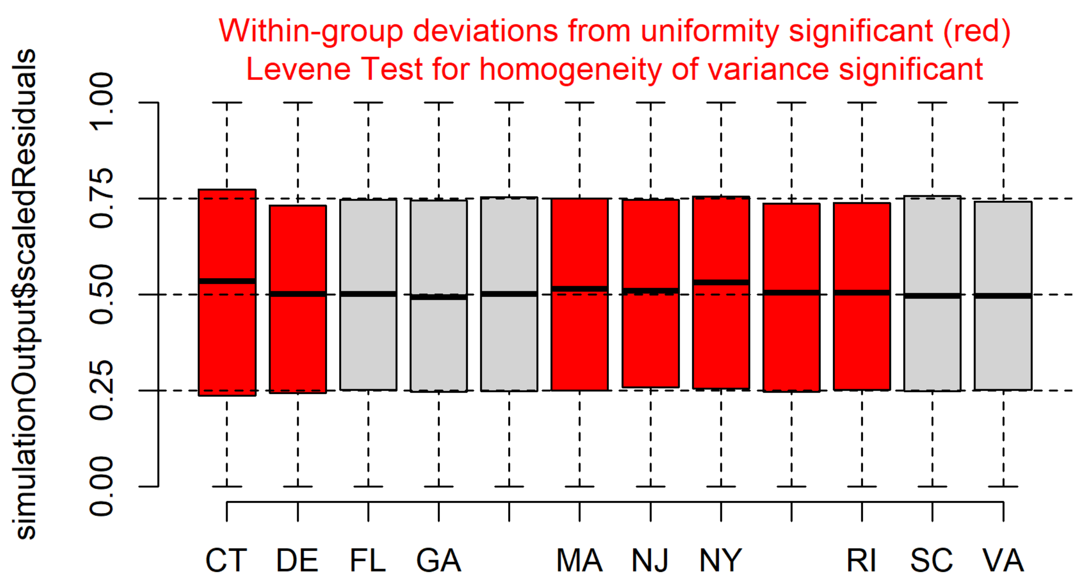

Figure 30: Simulated residuals by state for the guild trips MRIP index.

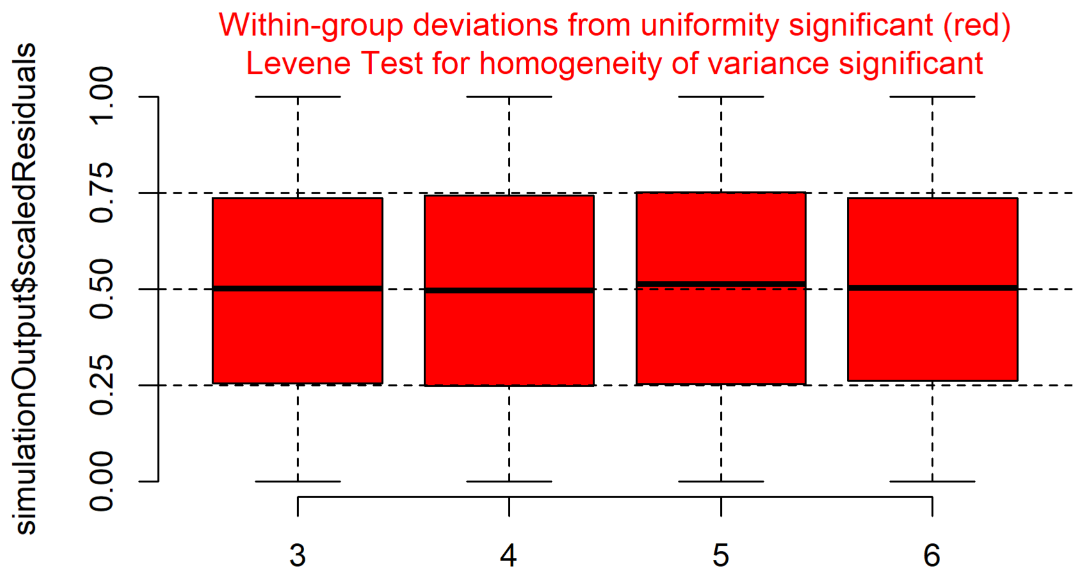

Figure 31: Simulated residuals by wave for the directed trips MRIP index.

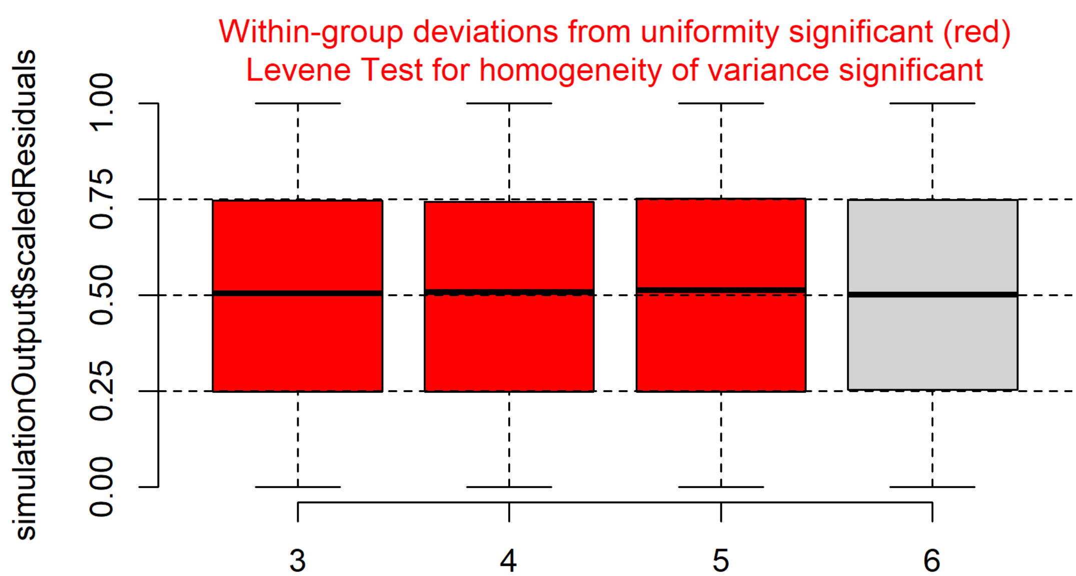

Figure 32: Simulated residuals for wave for the guild trips MRIP index.

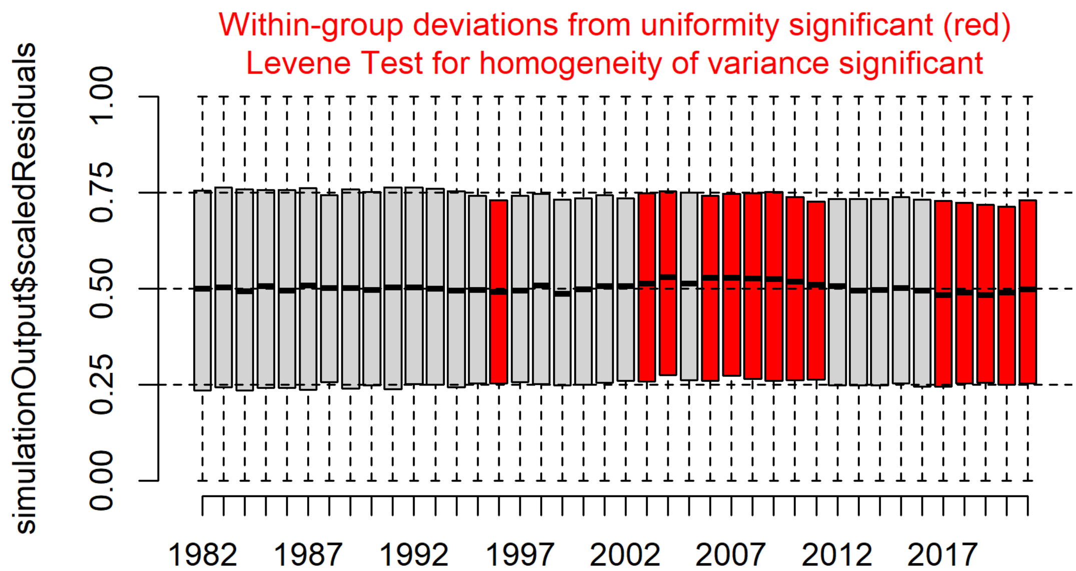

Figure 33: Simulated residuals by year for the directed trips MRIP index.

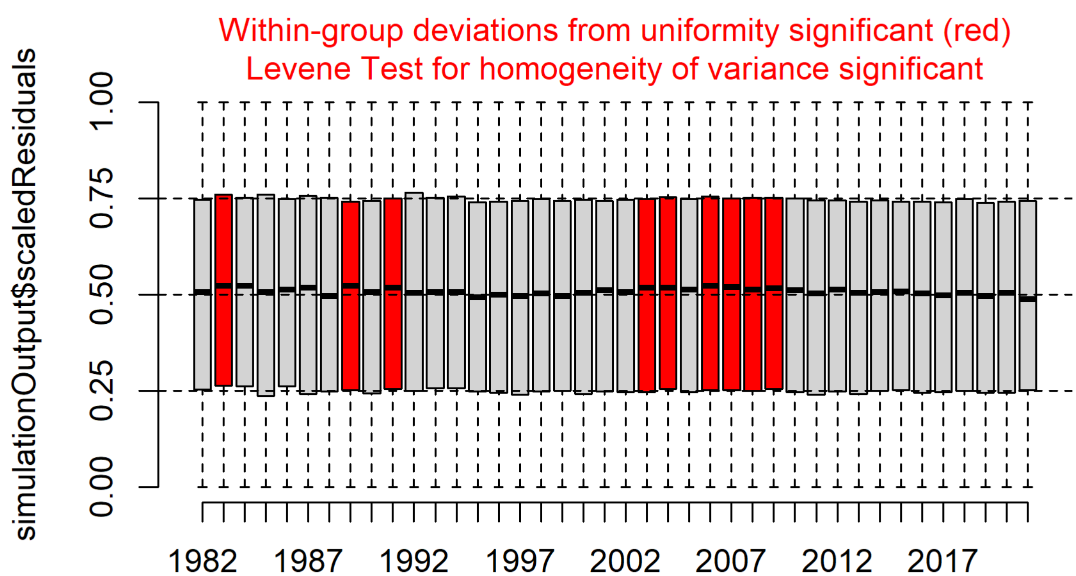

Figure 34: Simulated residuals for year for the guild trips MRIP index.

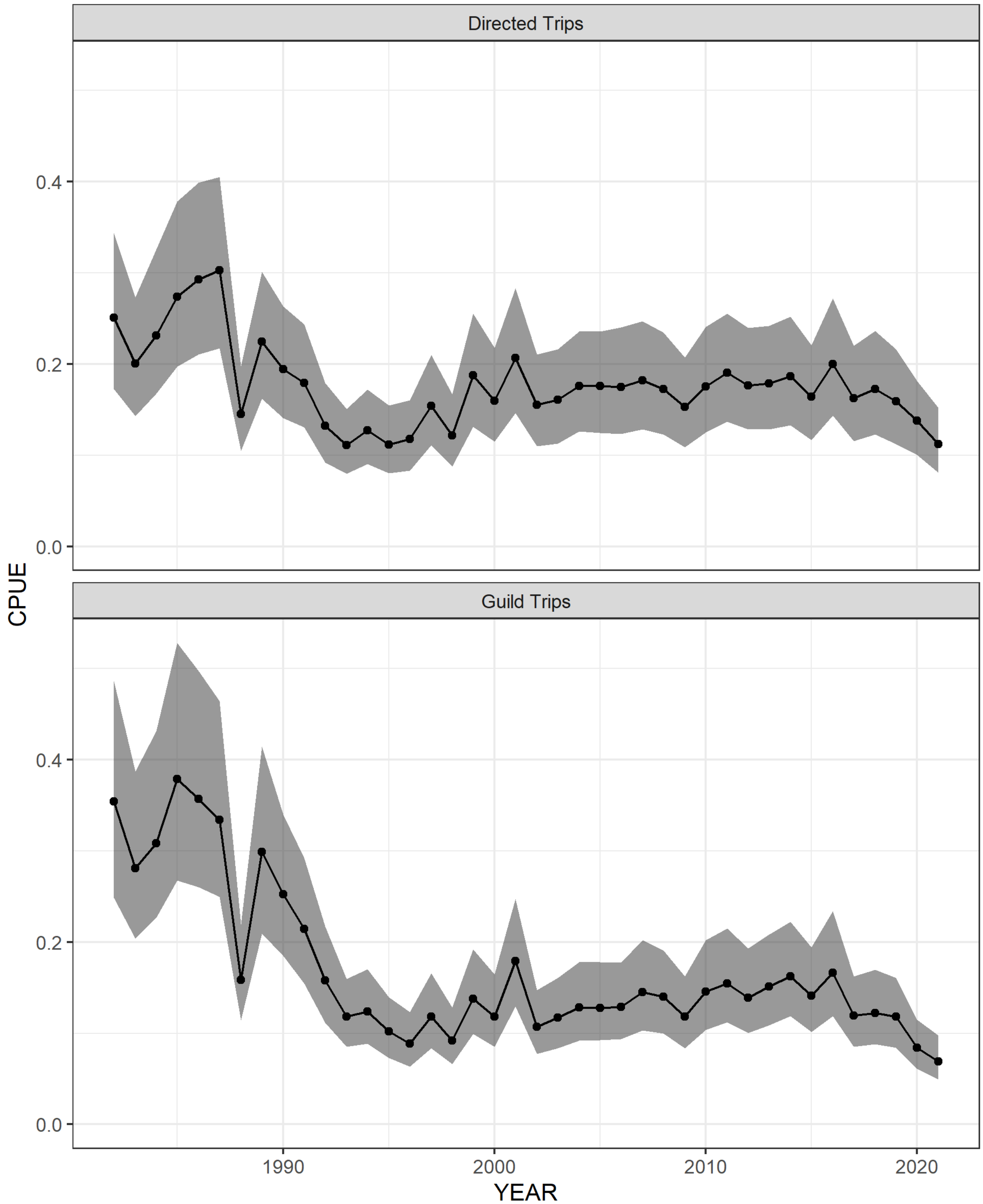

Figure 35: MRIP index of relative abundance derived from the directed trips (top) and guild trips (bottom) subset of intercepts. Shaded area indicates 95% confidence intervals.

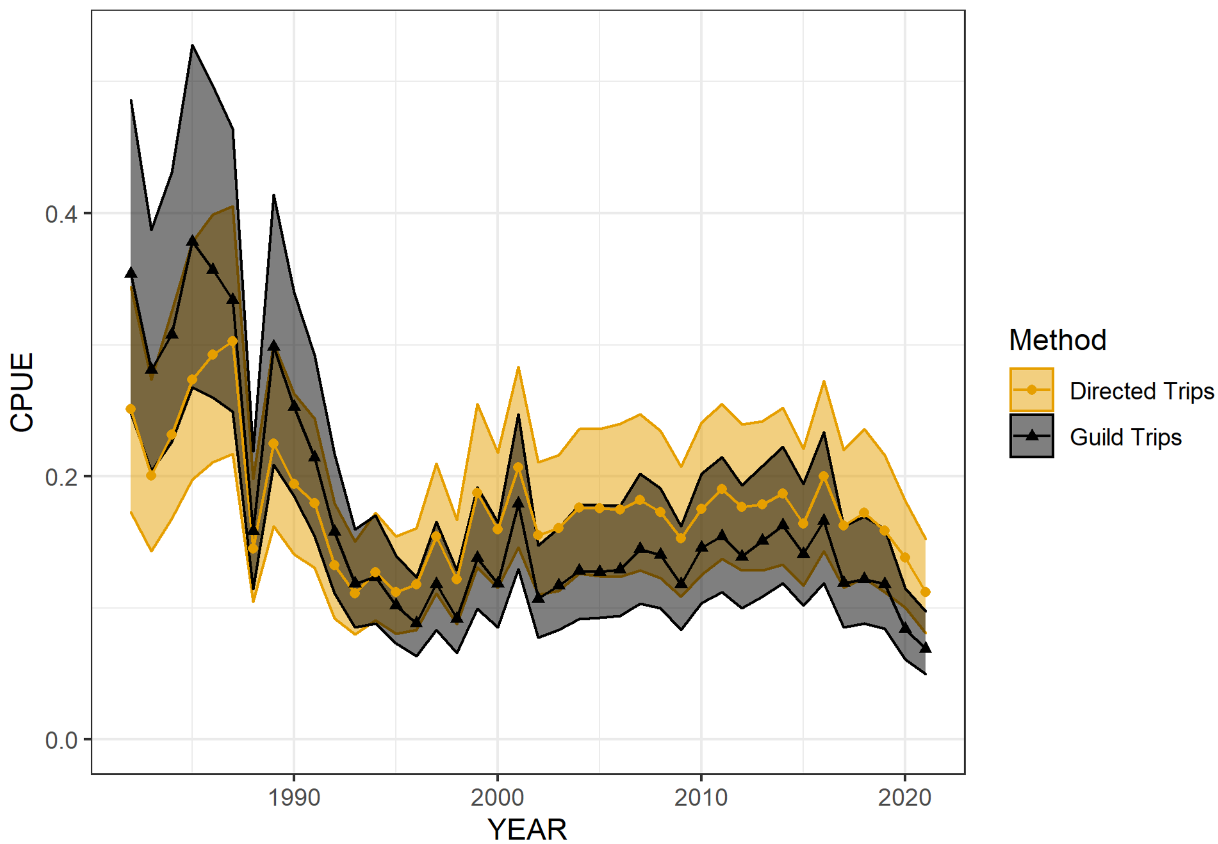

Figure 36: MRIP index of relative abundance for the directed trips and guild trips subset of intercepts plotted together with 95% confidence intervals.