Standardized Catch Rate Indices for Scamp (*Mycteroperca phenax*) and Yellowmouth Grouper (*Mycteroperca interstitialis*) during 1986-2017 by the U.S. Gulf of Mexico Headboat Recreational Fishery

Gulf and Caribbean Branch

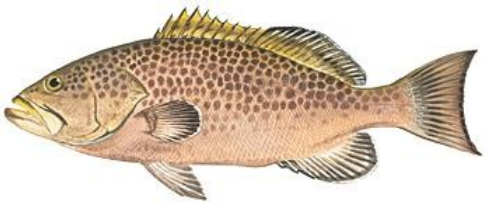
SEDAR68-DW-18

2 March 2020
Updated: 9 June 2020
Updated: 10 December 2020

This information is distributed solely for the purpose of pre-dissemination peer review. It does not represent and should not be construed to represent any agency determination or policy.

Please cite this document as:

Gulf and Caribbean Branch. 2020. Standardized Catch Rate Indices for Scamp (*Mycteroperca phenax*) and Yellowmouth Grouper (*Mycteroperca interstitialis*) during 1986-2017 by the U.S. Gulf of Mexico Headboat Recreational Fishery. SEDAR68-DW-18. SEDAR, North Charleston, SC. 42 pp.

Standardized Catch Rate Indices for Scamp (*Mycteroperca phenax*) and Yellowmouth Grouper (*Mycteroperca interstitialis*) during 1986-2017 by the U.S. Gulf of Mexico Headboat Recreational Fishery

Gulf and Caribbean Branch
Sustainable Fisheries Division
NOAA Fisheries - Southeast Fisheries Science Center
Corresponding Author Email (*skyler.sagarese@noaa.gov*)

Updated December 2020 to include Continuity details in Appendix C

Keywords

Catch, fishing effort, CPUE, recreational fisheries, headboat, Scamp and Yellowmouth Grouper

Abstract

A delta-lognormal index of abundance for the U.S. Gulf of Mexico headboat recreational fishery was constructed for the SEDAR68 Research Scamp and Yellowmouth Grouper stock assessment. The index in this document uses data from the Southeast Region Headboat Survey (SRHS) and was developed following improved data filtering techniques and modifications to the trip selection approach as implemented in the South Atlantic region. For the U.S. Gulf of Mexico, the SEDAR68 standardized index indicates catch rates were relatively low throughout the 1990s, increased during the 2000s, and have declined since 2011 to record low levels in 2016 and 2017.

Introduction

The recreational fishery in the Gulf of Mexico is surveyed by the Marine Recreational Information Program (MRIP) conducted by NOAA Fisheries (formerly the Marine Recreational Fisheries Statistics Survey, MRFSS), the Texas Marine Sport-Harvest Monitoring Program conducted by the Texas Parks and Wildlife Department (TPWD), and the Southeast Region Headboat Survey (SRHS) conducted by NOAA Fisheries. The SRHS has monitored catch and fishing effort from party (head) boats in the Gulf of Mexico since 1986. Data from the SRHS were used to construct an index of Scamp and Yellowmouth Grouper abundance in the U.S. Gulf of Mexico following the same procedures used in previous SEDAR assessments. The index was constructed using a delta-lognormal generalized linear model.

Materials and Methods

Data Source

The SRHS collects data on the catch and effort for individual headboat trips. Reported information includes landing date and location, vessel identification, the number of anglers, a single fishing location (10' x 10' rectangle of latitude and longitude) for the entire trip, trip duration and/or type (half/three-quarter/full/multi-day, day/night, morning/afternoon), and catch by species in number and weight.

Catch per unit effort (CPUE) was calculated on an individual trip basis. The CPUE for each trip was estimated as the number of Scamp and Yellowmouth Grouper landed on a trip divided by the fishing effort, where effort was the product of the number of anglers and the total hours fished. To estimate effort for each trip type (i.e., trip duration), the following assumptions were adopted: Half day trip = 5 hours fished; Three-quarter day trip = 7.5 hours fished, and Full day trip = 10 hours fished.

Data Filtering

The following data preparation and filtering techniques were applied to the 1986-2017 SRHS dataset:

1. Vessels that had fewer than 30 trips in the logbook database were excluded (33 vessels, resulted in 0.12% of trips removed). Logbooks submitted by vessels that participated infrequently in the fishery are likely to be less accurate and may add noise to the data. Even if a vessel fished infrequently for one year, the number of trips should be greater than 30.

2. Trips with 6 or fewer anglers were excluded (1.44% of trips). It is rare for a headboat to fish with few anglers. There is anecdotal information that headboats would sometimes fish with just the crew and that logbooks for these trips were submitted. Experienced crew are likely to be more efficient at catching fish than paying customers. Captains may also limit distance to reduce fuel costs for trips with few paying customers.

3. Observations were included from all states across the Gulf of Mexico (Florida/Alabama = 75.91%, Mississippi = 0.04%, Louisiana = 1.33%, and Texas = 22.72%).

4. Observations were included from half-day trips (11.59%), three-quarter day trips (30.13%), and full-day trips (44.96%).

5. Trips with possible errors in catch and effort information were excluded including trips with multiple records for a species (0.04% of trips removed), trips with potentially duplicated effort (0.24% of trips removed), trips with an unusually large number of target species (0.01% of trips removed), trips with the largest 0.5% values for catch for each region (0.44% of trips removed), trips with the largest 0.5% values for cpue for each region (0.5% of trips removed), and trips with the largest 0.5% values for anglers for each region (0.37% of trips removed).

6. Trips during the closed season for shallow-water groupers were excluded (1.91% of trips removed).

7. Trips that reached bag limits (0% of trips) and exceeded bag limits (0.02% of trips) for aggregate groupers were retained.

Subsetting Trips: Species Association

A method to infer targeting for each trip was used to develop the index because no direct targeting information was available. The Stephens and MacCall (2004) approach was used to restrict the dataset to trips that likely encountered Scamp and Yellowmouth Grouper based on the catch species composition. This approach was applied separately for the Eastern U.S. Gulf of Mexico and Western U.S. Gulf of Mexico due to suspected differences in species compositions between regions. Substantial differences in habitat type have been noted between regions, as the Eastern U.S. Gulf of Mexico is dominated more by hard bottom habitats whereas the Western U.S. Gulf of Mexico has less hard structure (SEDAR 2011). In applying the Stephens and MacCall (2004) approach, the species considered were limited to reef fish species that were on the headboat logbook forms across all years (**Table 1**). Species with seasonal or quota closures in recent years were also omitted because of the potential for erroneously removing trips likely to have caught Scamp and Yellowmouth Grouper during years of restrictions (**Figure 1**).

Standardization

A two-stage delta-lognormal generalized linear model (GLM; Lo et al. 1992) was used to standardize for variability and non-randomness in CPUE data collection methods not caused by the year effect (i.e., to factor out year to year variations in CPUE not due to changes in abundance). This method combines two separate generalized linear model (GLM) analyses of the proportion of trips that caught at least one Scamp and Yellowmouth Grouper (i.e., proportion of positive trips) and the catch rates of the positive trips to construct a single standardized index of abundance. In the first step, the proportion positive is modeled using a logit regression assuming a binomial distribution of the response variable. In the second step, the logarithm of CPUE on positive trips (those that caught the target species) was used as the response variable assuming a normal distribution and an identity link function. The two models were then combined to provide the final standardized index of abundance. Parameterization of each model was accomplished using a GLM procedure. For the lognormal models, the response variable, ln(*CPUE*), was calculated:

ln(CPUE) = ln(Catch) / (anglers x hours fished)

A forward stepwise regression approach was utilized within the GENMOD procedure of SAS 9.2 (SAS Institute, 2008). In this procedure, factors were added to the base model one at a time based on the percent reduction in deviance per degree of freedom. With each run of the model, the factor that caused the highest reduction in deviance was added to the base model (assuming the factor was significant based on a Chi-Square test with probability ≤ 0.05) until no factor reduced the percent deviance by the pre-specified level of 1%. Once a set of fixed factors was identified, first level interactions were examined. The significance of these interactions was evaluated between nested models using the likelihood ratio test. Interactions were screened and were only retained if the model improvement was significant according to the likelihood ratio test ($p< 0.0001$). Significant YEAR*FACTOR interaction terms were modeled as random effects.

The variation in catch rates by vessel was examined using a "repeated measures" approach (Littell et al., 1998). The term 'repeated measures' refers to multiple measurements taken over time on the same experimental unit (i.e. vessel). Specifying the repeated measure "VESSEL" and the subject "VESSEL(YEAR)" allows PROC MIXED to model the covariance structure of the data. This is particularly important because catch rates may vary by vessel and because catch rates by a given vessel that are close in time can have a higher correlation than those far apart in time (Littell et al., 1998).

Results of the binomial (proportion positive) and lognormal (mean CPUE on successful trips) models were then multiplied to attain a single index of abundance based on the year effect. The final delta-lognormal model was fit using the SAS macro GLIMMIX (glmm800MaOB.sas: Russ Wolfinger, SAS Institute) and the SAS procedure PROC MIXED (SAS Institute Inc. 1997) following the procedures by Lo et al. (1992).

Results and Discussion

Species Associations - Stephens and MacCall (2004) Approach - Eastern U.S. Gulf of Mexico

The minimum difference between the predicted and the observed number of trips that reported Scamp and Yellowmouth Grouper occurred at the probability threshold of 0.2 (**Figure 2A**). Predicted trips showed a general increasing trend throughout the time series, were underestimated early in the time series and overestimated at the end of the timeseries (**Figure 2B**). Trips with a predicted probability greater than the critical threshold probability were considered as trips that targeted Scamp and Yellowmouth Grouper (**Figure 2C**). Nominal CPUE was relatively similar before and after applying the Stephens and MacCall (2004) approach, with the exception of the mid-1980s and the mid-2000s (**Figure 2D**). This method retained 7.2% of the total trips, and 26.5% of trips that reported Scamp and Yellowmouth Grouper. Prior to trip selection, there were 170,116 trips and the proportion positive was 0.07, and after selection there were 12,181 trips and the proportion positive was 0.26.

The Stephens and MacCall (2004) trip subsetting approach identified 15 reef fish species which were captured with Scamp and Yellowmouth Grouper (**Table 2**; scientific names provided in **Table 1**). Red Porgy, Vermilion Snapper, Littlehead Porgy, Gray Snapper, and Almaco Jack were positively correlated to Scamp and Yellowmouth Grouper whereas White Grunt, Tomtate, Bank Sea Bass, and Sand Perch were negatively correlated.

Species Associations - Stephens and MacCall (2004) Approach - Western U.S. Gulf of Mexico

The minimum difference between the predicted and the observed number of trips that reported Scamp and Yellowmouth Grouper occurred at the probability threshold of 0.2 (**Figure 3A**). The trends in predicted and observed trips were very similar, with both gradually declining throughout the time series and increasing in recent years (**Figure 3B**). Trips with a predicted probability greater than the critical threshold probability were considered as trips that targeted Scamp and Yellowmouth Grouper (**Figure 3C**). Nominal CPUE was relatively similar before and after applying the Stephens and MacCall (2004) approach, with the exception of the earliest years (**Figure 3D**). This method retained 6.5% of the total trips, and 36.3% of trips that reported Scamp and Yellowmouth Grouper. Prior to trip selection, there were 58,868 trips and the

proportion positive was 0.06, and after selection there were 3,848 trips and the proportion positive was 0.35.

The Stephens and MacCall (2004) trip subsetting approach identified 10 reef fish species which were captured with Scamp and Yellowmouth Grouper (**Table 3**; scientific names provided in **Table 1**). Vermilion Snapper, Red Porgy, Tomtate, Rock Hind, and Almaco Jack were positively correlated to Scamp and Yellowmouth Grouper. No negatively associated species were identified.

Trends in Species Associations Between Regions for the Stephens and MacCall (2004) approach

Trends in the U.S. Gulf of Mexico tended to be dominated by the Eastern U.S. Gulf of Mexico (correlation = 0.92), with associations in the Western U.S. Gulf of Mexico less similar to the Eastern U.S. Gulf of Mexico (correlation = 0.44) (**Figure 4**).

The derived probability threshold and proportion positive before applying the Stephens and MacCall (2004) approach were similar across regions (**Figure 5**). However, the percent of trips retained and the proportion positive were higher in the Western U.S. Gulf of Mexico compared to the Eastern U.S. Gulf of Mexico and both regions combined (**Figure 5**).

Variable Selection

The following factors were treated as fixed effects and were examined as possible influences on the proportion of positive trips and on the catch rates of positive trips:

Name	DF	Details
Year	32	1986-2017
Season	4	Dec-Feb, Mar-May, Jun-Aug, Sep-Nov
Area	4	CenTX_SWTX, NWFL_AL, NWTX_LA, SW_FL
Trip Type*	3	Full day, Half day, Three quarter day
Anglers*	7	7-10, 11-20, 21-30, 41-50, 51-60, 61+

*Only explored as factors for modeling success because these factors were confounded with effort for the CPUE response variable in the lognormal model.

Annual Abundance Indices

Final deviance tables are included in **Table 4**. The final models for the binomial (i.e., proportion positive) and lognormal (catch rate of positive trips) components were:

$$ProportionPositive = YEAR$$

$$ln(CPUE) = YEAR + AREA + SEASON + YEAR * AREA$$

For the binomial model, year was the only significant variable (**Table 4**).

Diagnostics for each component of the GLM are provided in **Figure 6** and **Figure 7**. The overdispersion parameter for the binomial component was undefined. The binomial model consistently estimated the proportion of positive trips (**Figure 6A**). The proportion positive

ranged from 0.18 to 0.6, and has generally remained between 0.24 and 0.35. Residual analysis of the binomial model showed no obvious patterns in the residuals by year (**Figure 6B**).

The lognormal model results suggest a good fit to the data and indicated that the assumption of a lognormal distribution for positive catch rates was appropriate for the data (**Figure 7A-B**). Residual analysis of the lognormal model also showed no obvious patterns in the residuals by year (**Figure 7C**), area (**Figure 7D**) or season (**Figure 7E**).

Table 5 summarizes the standardized index, corresponding lower and upper 95% confidence limits, annual coefficients of variation, nominal CPUE, and number of trips. Nominal CPUE values fell within the 95% confidence interval of the standardized index, with the exception of the values in years 1987, 1991 and 2003 (**Figure 8**). Relative abundance remained above the time series mean in the first few years of the index, declined to below the time series mean during most of the 1990s and began to increase in the 2000s. However, the index showed a continuous decline from 2011 to the end of the time series. Relative abundance peaked in 1986, the first year of the time series, and was at the lowest value in 2017, the last year of the time series (**Figure 8**).

Comments on Adequacy for Assessment

The headboat index presented in this working paper is based on improved methodology compared to the continuity approach for developing indices of abundance for Gulf reef fish stocks from the SRHS (**Appendix B**). The index for Scamp and Yellowmouth Grouper is associated with moderate variability with a mean CV of 0.15 (range: 0.13 – 0.17), which is lower compared to other Gulf species (e.g., Red Grouper CV range: 0.49 – 0.8; Sagarese and Rios 2018). Previous Gulf reef fish assessments have included this index because it contains one of the longest time series and has widespread spatial coverage compared to other indices.

Additional research is needed to explore alternative trip selection approaches which may be more appropriate for the U.S. Gulf of Mexico and South Atlantic recreational fisheries.

References

Littell, R.C., P.R. Henry and C.B. Ammerman. 1998. Statistical analysis of repeated measures data using SAS procedures. J. Anim. Sci. 76:1216-1231.

Lo, N.C., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49: 2515-2526.

Sagarese, S., and A. Rios. 2018. Standardized Catch Rates of Red Grouper (*Epinephelus morio*) from the U.S. Headboat Fishery in the Gulf of Mexico, 1986-2017. SEDAR61-WP-05. SEDAR, North Charleston, SC. 13 pp.

SAS Institute Inc. 1997, SAS/STAT Software: Changes and Enhancements through Release 6.12. Cary, NC: Sas Institute Inc., 1997. 1167 pp.

SEDAR (Southeast Data Assessment and Review). 2011. SEDAR22 Gulf of Mexico Yellowedge Grouper Stock Assessment Report. 423 pp.

Stephens, A., and A. MacCall. 2004. A multispecies approach to subsetting logbook data for purposes of estimating CPUE. Fish. Res. 70:299-310.

Tables

Table 1. Reef fish species listed on headboat logbook forms since 1986.

Common Name	Scientific Name
African Pompano	*Alectis ciliaris*
Almaco Jack	*Seriola rivoliana*
Angelfish	*Pomacanthidae*
Bank Sea Bass	*Centropristis ocyurus*
Great Barracuda	*Sphyraena barracuda*
Bigeye	*Priacanthus arenatus*
Blackfin Snapper	*Lutjanus buccanella*
Blue Runner	*Caranx crysos*
Bluefish	*Pomatomus saltatrix*
Blueline Tilefish	*Caulolatilus microps*
Bluestriped Grunt	*Haemulon sciurus*
Atlantic Bonito	*Sarda sarda*
Cobia	*Rachycentron canadum*
Cubera Snapper	*Lutjanus cyanopterus*
Dolphin	*Coryphaena hippurus*
Gag	*Mycteroperca microlepis*
Gray Snapper	*Lutjanus griseus*
Gray Triggerfish	*Balistes capriscus*
Graysby	*Epinephelus cruentatus*
Greater Amberjack	*Seriola dumerili*
Hogfish	*Lachnolaimus maximus*
Jolthead Porgy	*Calamus bajonado*
King Mackerel	*Scomberomorus cavalla*
Knobbed Porgy	*Calamus nodosus*
Lane Snapper	*Lutjanus synagris*
Littlehead Porgy	*Calamus proridens*
Mutton Snapper	*Lutjanus analis*
Queen Triggerfish	*Balistes vetula*
Rainbow Runner	*Elagatis bipinnulata*
Red Grouper	*Epinephelus morio*
Red Hind	*Epinephelus guttatus*
Red Porgy	*Pagrus pagrus*

Table 1 Continued. Reef fish species listed on headboat logbook forms since 1986.

Common Name	Scientific Name
Red Snapper	*Lutjanus campechanus*
Rock Hind	*Epinephelus adscensionis*
Sand Perch	*Diplectrum formosum*
Sand Tilefish	*Malacanthus plumieri*
Scamp	*Mycteroperca phenax*
Silk Snapper	*Lutjanus vivanus*
Atlantic Spadefish	*Chaetodipterus faber*
Spanish Mackerel	*Scomberomorus maculatus*
Spottail Pinfish	*Diplodus holbrooki*
Spottail Porgy	*Sparidae*
Squirrelfish	*Holocentrus adscensionis*
Tomtate	*Haemulon aurolineatum*
Vermilion Snapper	*Rhomboplites aurorubens*
White Grunt	*Haemulon plumieri*
Whitebone Porgy	*Calamus leucosteus*
Yellowfin Grouper	*Mycteroperca venenosa*
Yellowmouth Grouper	*Mycteroperca interstitialis*

Table 2. Association coefficients of other species with Scamp and Yellowmouth Grouper for the Eastern U.S. Gulf of Mexico. Positive numbers indicate a positive correlation.

Coefficient	Common Name
0.901	Red Porgy
0.818	Vermilion Snapper
0.735	Littlehead Porgy
0.578	Gray Snapper
0.574	Almaco Jack
0.491	Jolthead Porgy
0.279	Knobbed Porgy
0.091	Whitebone Porgy
0.054	Lane Snapper
0.050	Blue Runner
0.019	Hogfish
-0.087	Sand Perch
-0.285	Bank Sea Bass
-0.468	Tomtate
-0.797	White Grunt

Table 3. Association coefficients of other species with Scamp and Yellowmouth Grouper for the Western U.S. Gulf of Mexico. Positive numbers indicate a positive correlation.

Coefficient	Common Name
1.963	Vermilion Snapper
1.281	Red Porgy
0.860	Tomtate
0.834	Rock Hind
0.569	Almaco Jack
0.521	Whitebone Porgy
0.470	African Pompano
0.437	Lane Snapper
0.210	Blue Runner
0.096	Gray Snapper

Table 4. Deviance tables for the regression models for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico. The table shows the order of the factors as they were sequentially added to each model. Fit diagnostics listed for each factor were the diagnostics from a model that included that factor and all of the factors listed above it in the tables below.

Factor	DF	Deviance	Residual DF	Residual Deviance	AIC	Deviance Reduced	Log likelihood	Likelihood Ratio Test
Binomial								
Null	1	19168	16028	19168	19168	-	-9584	-
Year	32	18561	15997	607	18561	2.98%	-9280	607.6
Lognormal								
Null	1	2598	4573	2598	10393	-	-5196	-
Area	4	2331	4570	266	9897	10.21%	-4948	495.8
Year	32	2137	4539	194	9500	7.70%	-4750	397.4
Season	4	2054	4536	82	9319	3.81%	-4659	180.8
Area*Year	85	1921	4452	132	9013	4.70%	-4506	305.8

Table 5. Numbers (N) of total and positive trips, proportion of positive trips (PPT), relative nominal CPUE, and standardized abundance index statistics for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico.

Year	N	Positive N	PPT	Relative Nominal CPUE	Relative Index	Lower 95% CI	Upper 95% CI	CV
1986	240	144	0.600	1.826	2.015	1.534	2.648	0.137
1987	317	144	0.454	1.005	1.384	1.046	1.833	0.141
1988	365	163	0.447	1.248	1.477	1.137	1.919	0.131
1989	352	90	0.256	0.667	0.817	0.624	1.070	0.135
1990	367	120	0.327	0.964	1.172	0.899	1.529	0.133
1991	393	100	0.254	0.734	0.979	0.744	1.289	0.138
1992	471	107	0.227	0.582	0.708	0.542	0.923	0.133
1993	411	102	0.248	0.699	0.745	0.571	0.972	0.134
1994	506	155	0.306	0.877	0.863	0.662	1.125	0.133
1995	493	165	0.335	0.986	1.208	0.923	1.583	0.136
1996	385	99	0.257	0.793	0.846	0.639	1.120	0.141
1997	445	108	0.243	0.743	0.764	0.562	1.038	0.154
1998	336	101	0.301	0.816	0.967	0.721	1.298	0.148
1999	268	49	0.183	0.665	0.679	0.491	0.938	0.163
2000	389	98	0.252	0.666	0.806	0.600	1.083	0.148
2001	516	91	0.176	0.687	0.667	0.489	0.911	0.156
2002	476	125	0.263	1.223	1.005	0.756	1.338	0.144
2003	492	108	0.220	1.234	0.791	0.579	1.082	0.157
2004	317	121	0.382	1.520	1.329	1.006	1.757	0.140
2005	359	141	0.393	1.427	1.287	0.972	1.704	0.141
2006	349	86	0.246	1.286	0.943	0.687	1.294	0.159
2007	377	146	0.387	1.643	1.546	1.126	2.124	0.160
2008	618	223	0.361	1.563	1.440	1.075	1.929	0.147
2009	716	198	0.277	1.066	0.912	0.685	1.214	0.144
2010	286	66	0.231	0.832	0.708	0.505	0.994	0.171
2011	438	230	0.525	2.068	1.757	1.301	2.372	0.151
2012	680	236	0.347	1.223	1.066	0.813	1.397	0.136
2013	826	197	0.238	0.663	0.676	0.490	0.932	0.162
2014	934	228	0.244	0.658	0.733	0.550	0.977	0.144
2015	957	280	0.293	0.747	0.785	0.589	1.045	0.144
2016	1080	197	0.182	0.448	0.461	0.348	0.611	0.141
2017	870	156	0.179	0.441	0.460	0.336	0.629	0.158

Figures

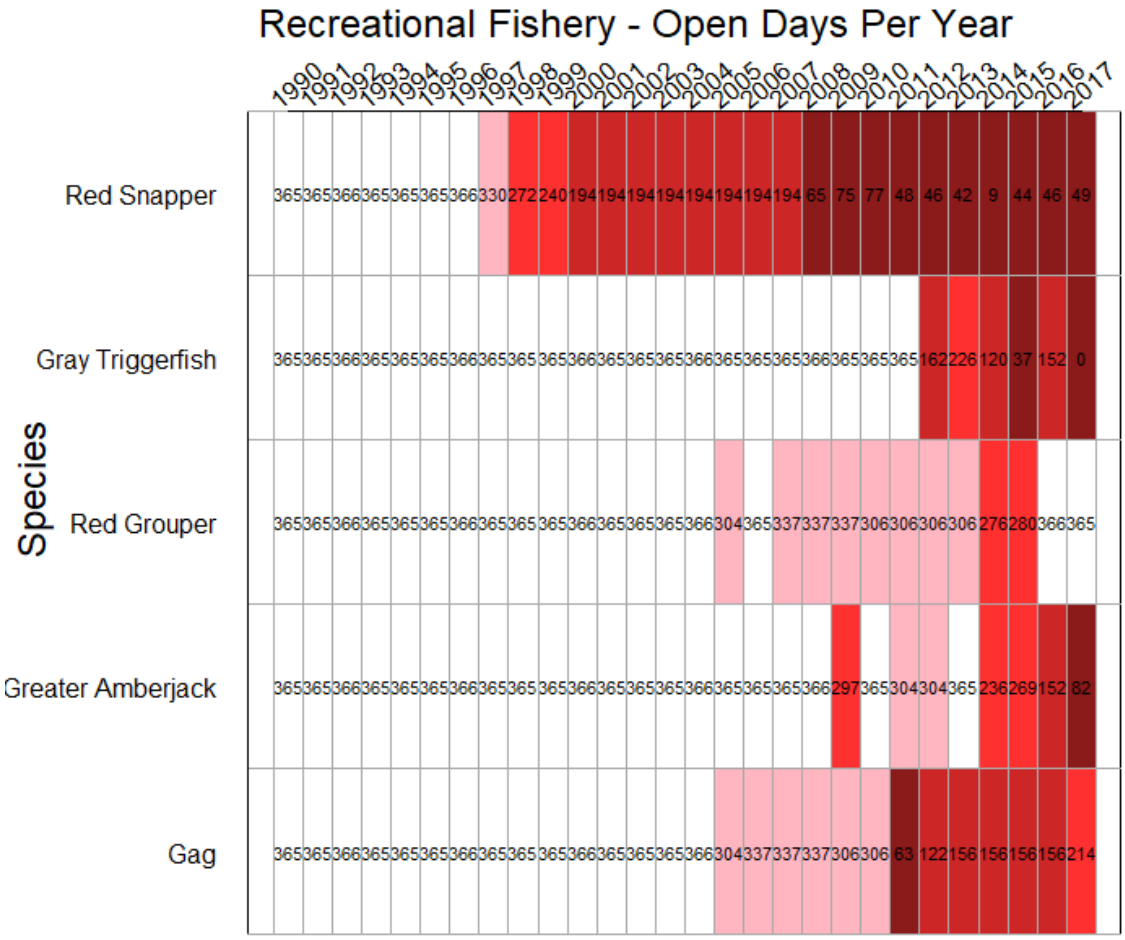


Figure 1. Species removed from the Stephens and MacCall (2004) trip selection approach for defining Scamp and Yellowmouth Grouper trips due to seasonal or complete closures.

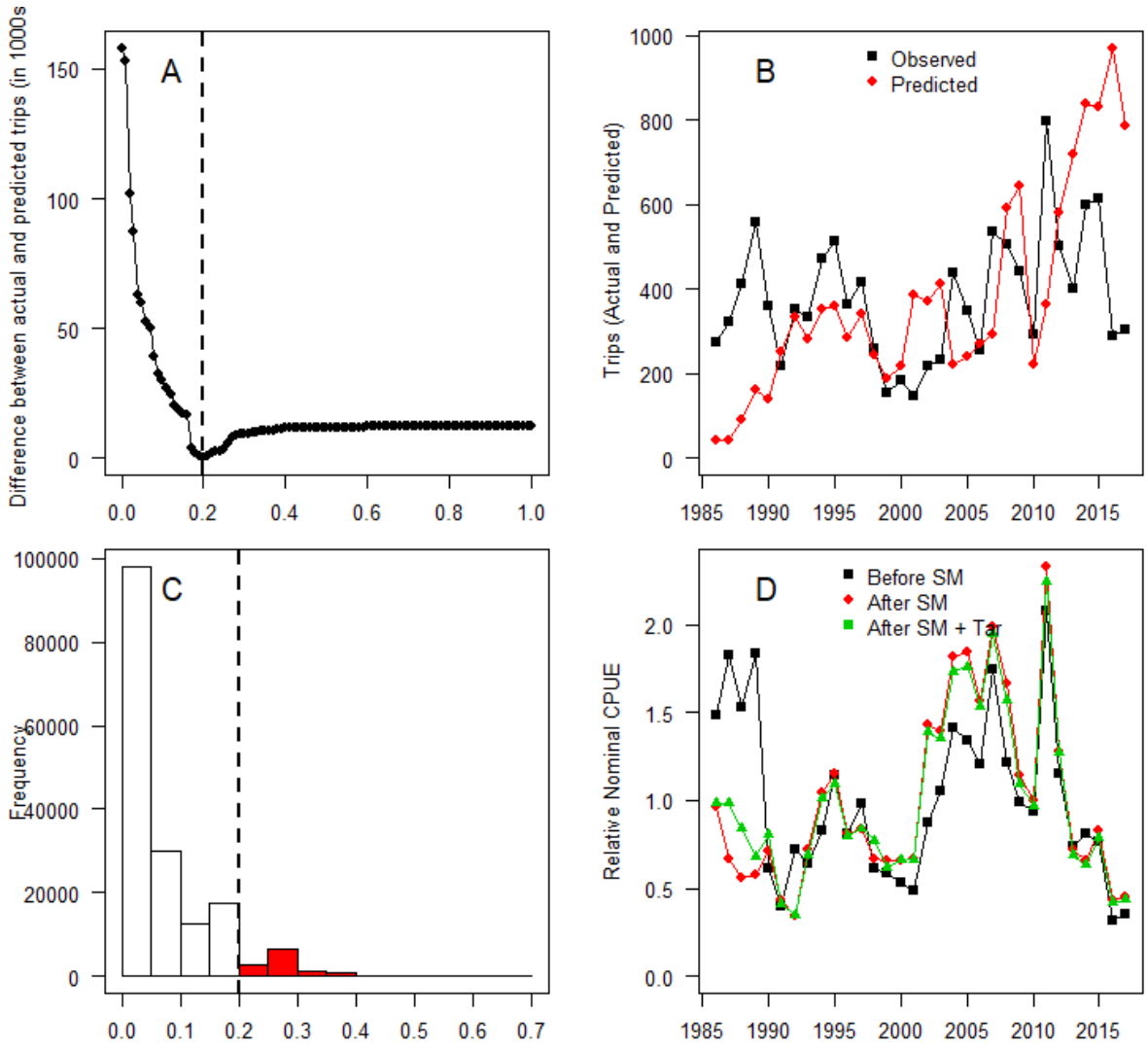


Figure 2. Stephens and MacCall (2004) trip selection diagnostics for the Eastern U.S. Gulf of Mexico. (A) The difference between the number of records in which Scamp and Yellowmouth Grouper are observed and the number in which they are predicted to occur for each probability threshold; (B) the number of actual and predicted trips; (C) Histogram of probabilities generated by the species-based regression (trips that targeted Scamp and Yellowmouth Grouper given in red); and (D) Nominal CPUE before ("Before SM") and after ("After SM") Stephens and MacCall (2004) trip selection ("After SM + Tar" = also includes all trips where the target species was caught). The dashed vertical line indicates the critical value where false prediction is minimized.

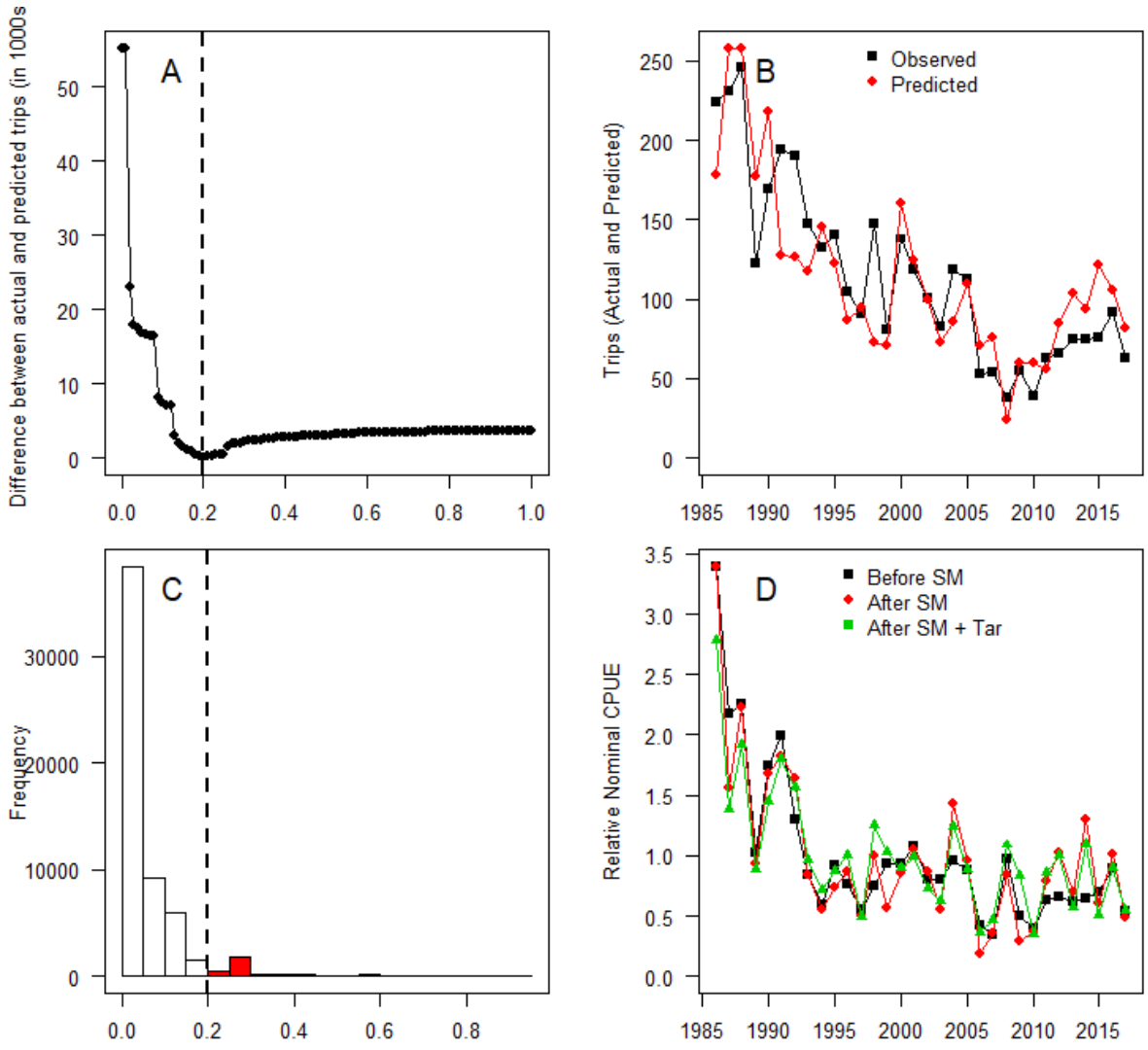


Figure 3. Stephens and MacCall diagnostics for the Western U.S. Gulf of Mexico. (A) The difference between the number of records in which Scamp and Yellowmouth Grouper are observed and the number in which they are predicted to occur for each probability threshold; (B) the number of actual and predicted trips; (C) Histogram of probabilities generated by the species-based regression (trips that targeted Scamp and Yellowmouth Grouper given in red); and (D) Nominal CPUE before ("Before SM") and after ("After SM") Stephens and MacCall (2004) trip selection ("After SM + Tar" = also includes all trips where the target species was caught). The dashed vertical line indicates the critical value where false prediction is minimized.

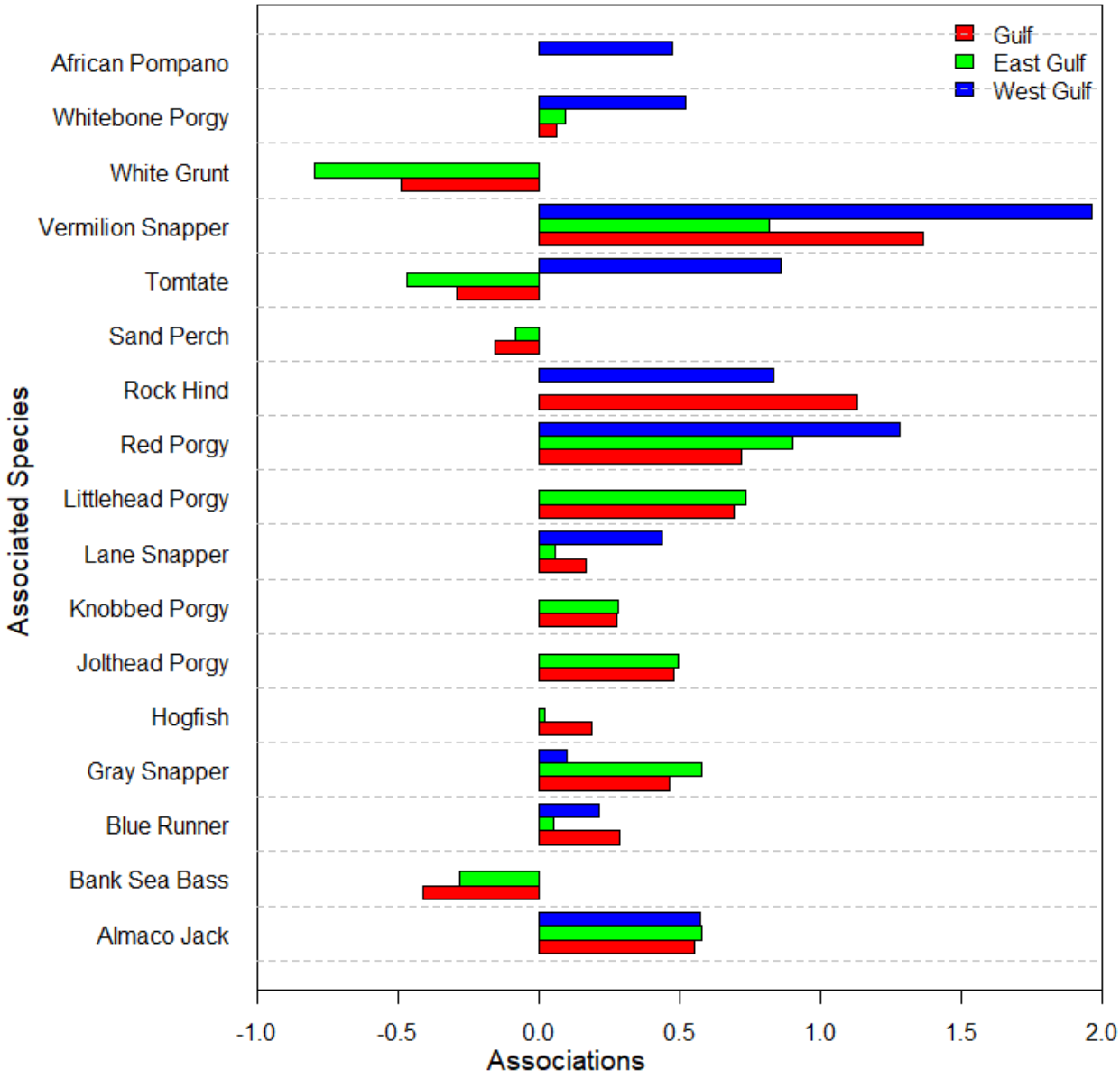


Figure 4. Association coefficients of other species with Scamp and Yellowmouth Grouper across regions in the U.S. Gulf of Mexico. Positive numbers indicate a positive correlation.

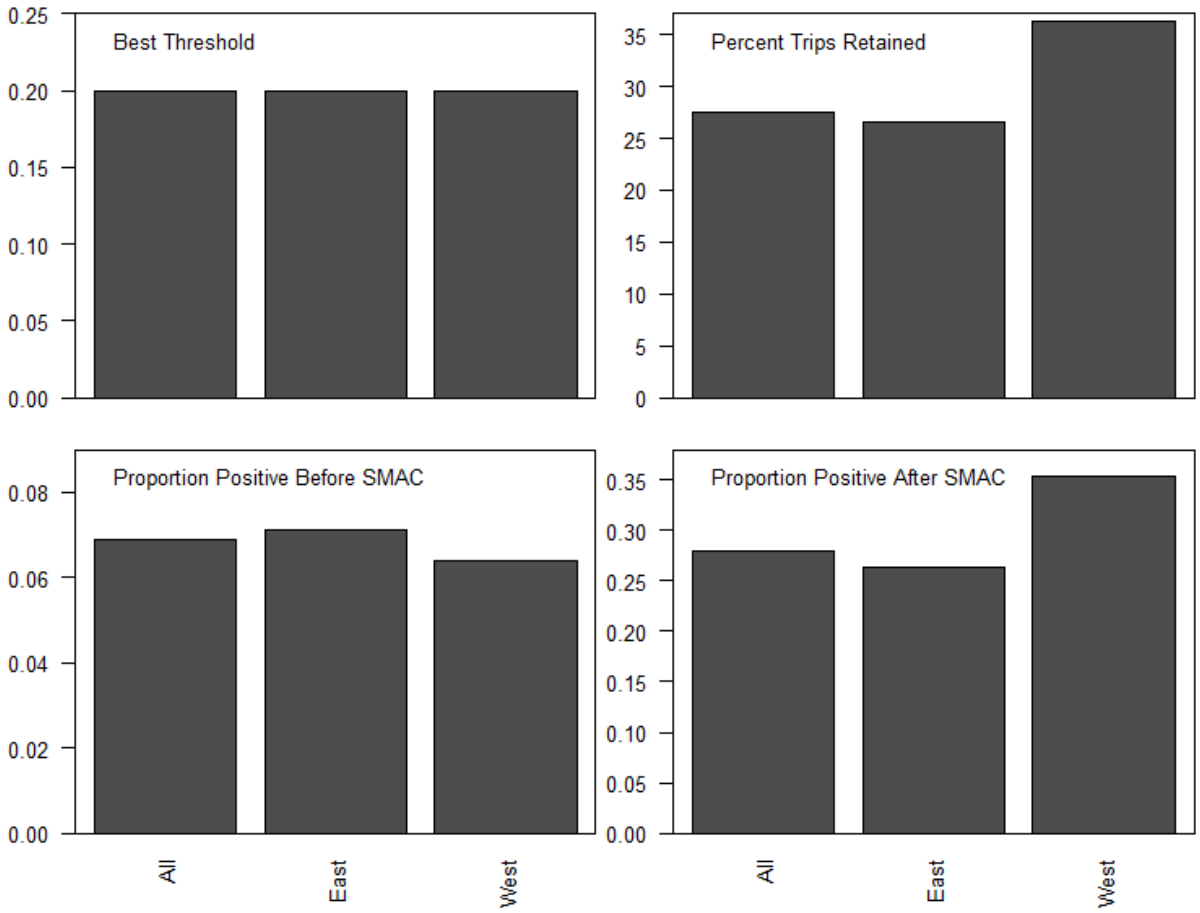


Figure 5. Stephens and MacCall (2004) statistics across regions for associations with Scamp and Yellowmouth Grouper.

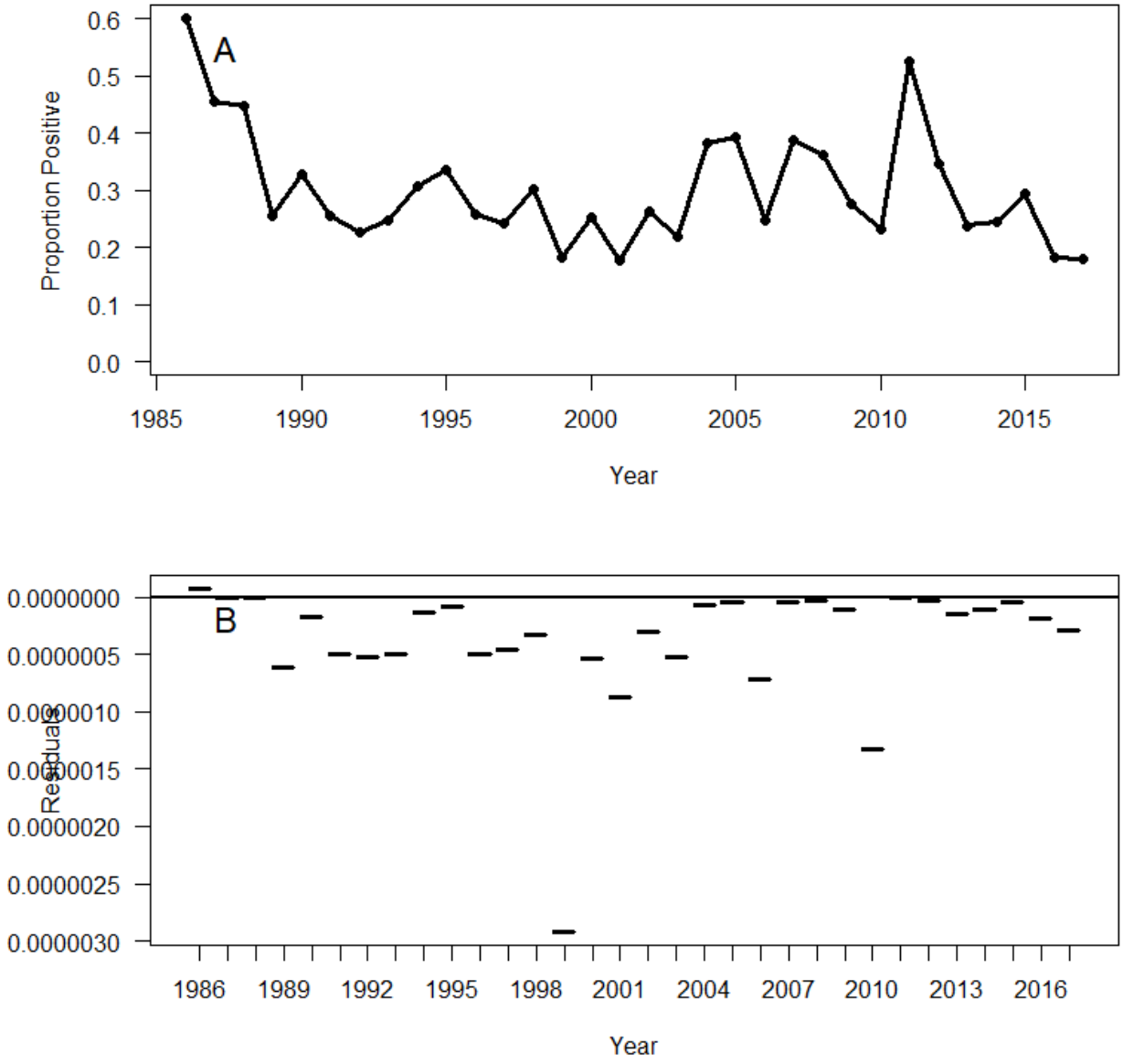


Figure 6. Diagnostic plots for the binomial model for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico. Shown here are the predicted (solid line) and observed proportion of positive trips by year (A) and the residuals from the binomial model by year (B). Note that the observed proportions are below the predicted proportions.

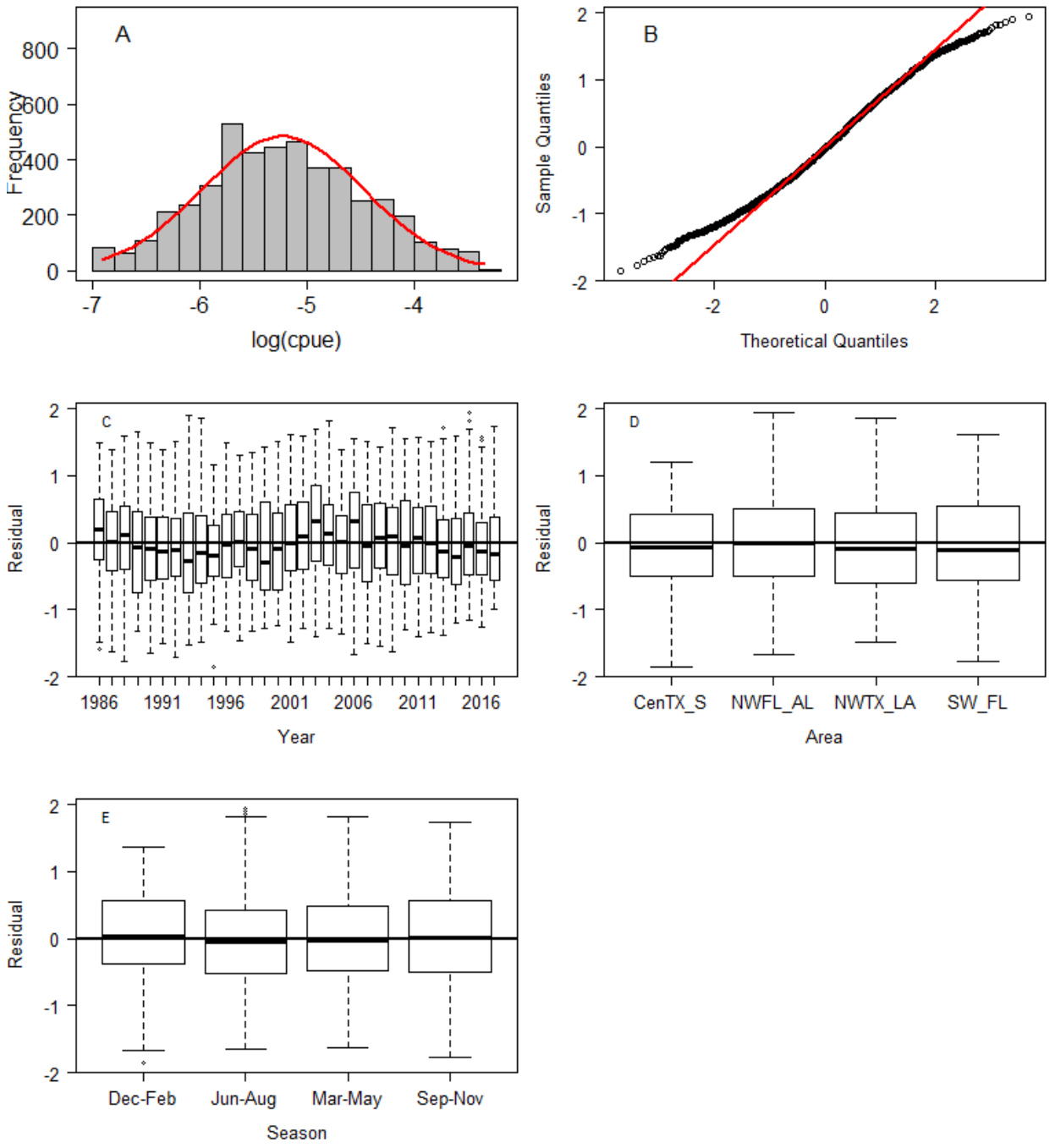


Figure 7. Diagnostic plots for the lognormal model of catch rates on positive trips for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico. Shown here are the frequency distribution of catch rates (A), the cumulative normalized residuals (B), and the distribution of residuals by year (C), area (D) and season (E). The red lines represent the expected normal distribution.

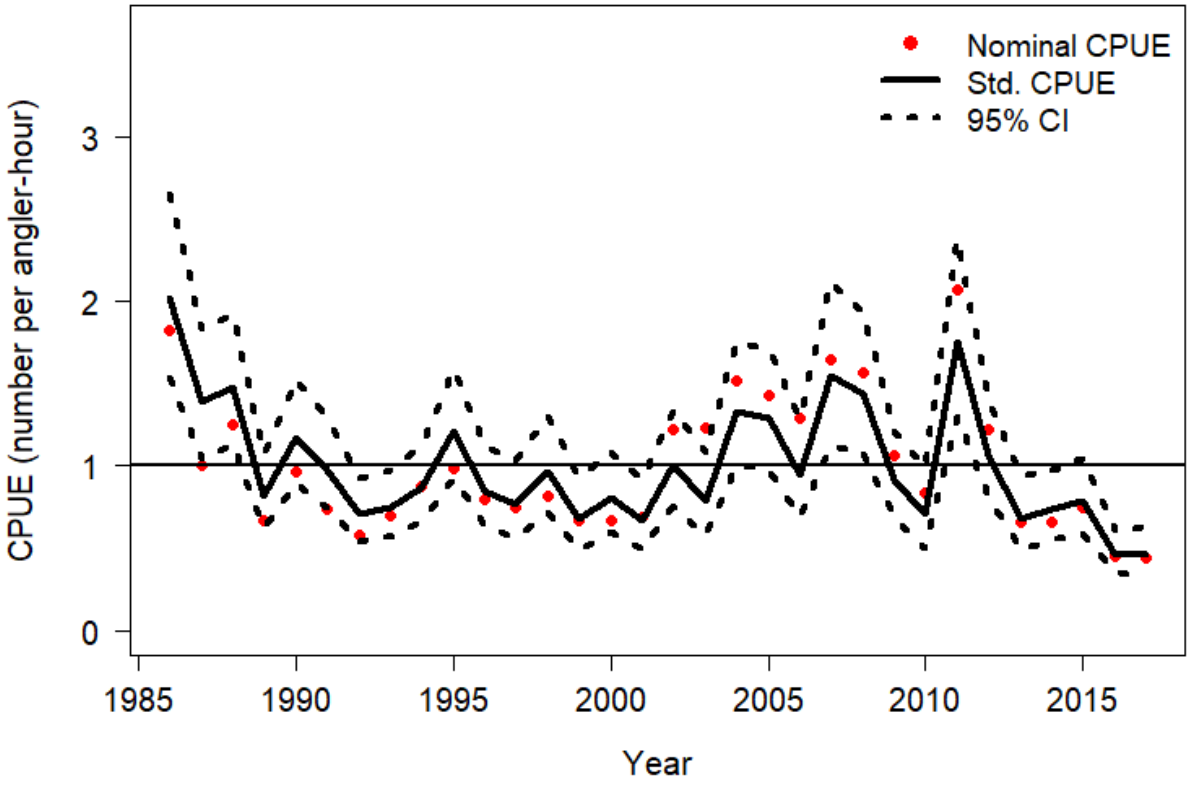


Figure 8. Standardized index with 95% confidence interval, and nominal CPUE for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico. The index was scaled to the mean value of the entire time series.

Appendix A

Table A1. Number of trips for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico

Year	CenSWTX	NWTX	ALNWFL	SWFL	0.5day	0.75day	Fullday	Dec-Feb
1986	31	163	26	20	6	12	222	8
1987	21	249	38	9	3	6	308	28
1988	38	230	84	13	8	25	332	44
1989	18	168	153	13	22	35	295	24
1990	48	178	109	32	17	43	307	21
1991	42	98	231	22	32	100	261	23
1992	58	78	307	28	13	123	335	17
1993	49	79	259	24	13	68	330	30
1994	69	84	343	10	44	112	350	32
1995	56	77	352	8	96	85	312	32
1996	39	55	278	13	55	94	236	14
1997	46	52	345	2	76	97	272	7
1998	30	54	251	1	13	138	185	26
1999	14	66	186	2	32	82	154	20
2000	25	142	218	4	21	115	253	12
2001	26	103	380	7	34	240	242	35
2002	56	46	370	4	51	257	168	20
2003	27	50	415	4	59	260	173	10
2004	22	69	222	2	24	154	139	15
2005	38	77	242	1	10	161	188	21
2006	16	59	273	1	47	183	119	13
2007	27	51	298	4	57	195	125	19
2008	18	10	586	3	70	406	142	26
2009	22	47	644	1	121	446	149	36
2010	13	48	224	2	11	152	123	7
2011	13	45	378	5	39	282	117	11
2012	35	55	585	2	50	458	172	25
2013	36	69	719	8	119	288	419	33
2014	23	73	830	6	147	364	423	59
2015	34	89	828	10	142	346	469	64
2016	23	86	961	7	150	390	540	75
2017	14	71	778	20	104	333	433	56
Total	1027	2821	11913	288	1686	6050	8293	863

Table A1 Continued. Number of trips for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico

Year	Mar-May	Jun-Aug	Sep-Nov	1-10	11-20	21-30	31-40	41-50	51-60	61+
1986	52	123	57	18	53	54	34	38	19	24
1987	88	134	67	13	43	65	43	47	54	52
1988	112	142	67	21	74	66	61	49	34	60
1989	81	152	95	14	59	64	60	44	44	67
1990	74	200	72	39	63	56	71	52	48	38
1991	73	213	84	26	61	84	67	71	39	45
1992	114	188	152	19	113	105	96	56	48	34
1993	97	192	92	20	87	91	86	57	31	39
1994	106	241	127	46	105	115	82	71	40	47
1995	129	266	66	50	102	109	73	103	33	23
1996	86	227	58	45	86	86	60	62	24	22
1997	100	244	94	53	131	95	63	46	20	37
1998	92	185	33	24	75	94	69	31	30	13
1999	114	130	4	32	51	56	54	24	25	26
2000	96	188	93	38	75	67	66	35	32	76
2001	159	245	77	80	131	114	82	33	26	50
2002	105	278	73	67	99	127	94	33	21	35
2003	134	255	93	43	110	133	102	45	26	33
2004	93	166	43	30	68	77	58	23	21	40
2005	127	173	38	29	75	86	84	32	18	35
2006	82	183	71	25	62	81	83	20	32	46
2007	106	202	50	19	56	112	98	19	30	43
2008	133	377	82	34	110	171	224	39	23	17
2009	142	415	123	27	149	182	250	40	30	38
2010	74	114	91	13	59	67	64	25	24	34
2011	66	292	69	10	53	92	152	39	31	61
2012	121	351	183	30	127	149	186	78	45	65
2013	144	471	178	38	148	212	209	64	67	88
2014	186	536	153	17	114	220	301	123	57	102
2015	221	497	175	16	125	228	304	80	95	109
2016	225	626	154	25	163	266	279	101	110	136
2017	201	464	149	39	148	208	226	81	66	102
Total	3733	8470	2963	1000	2975	3732	3781	1661	1243	1637

Table A2. Number of positive trips for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico.

Year	CenSWTX	NWTX	ALNWFL	SWFL	0.5day	0.75day	Fullday	Dec-Feb
1986	23	106	8	7	1	6	137	3
1987	16	113	7	8	3	3	138	21
1988	24	112	16	11	1	6	156	20
1989	9	38	35	8	1	6	83	10
1990	24	64	23	9	6	10	104	9
1991	22	45	30	3	2	20	78	7
1992	29	28	42	8	1	15	91	8
1993	16	27	53	6	0	11	91	12
1994	17	22	108	8	14	20	121	12
1995	17	14	128	6	60	16	89	9
1996	9	16	68	6	7	23	69	3
1997	7	13	87	1	27	22	59	3
1998	9	22	70	0	1	42	58	8
1999	6	15	28	0	2	13	34	6
2000	6	46	45	1	1	18	79	2
2001	6	27	58	0	4	44	43	9
2002	8	15	100	2	3	77	45	8
2003	6	7	95	2	7	70	31	9
2004	7	27	85	0	4	56	61	7
2005	11	32	98	1	2	52	87	9
2006	2	9	74	0	2	48	36	3
2007	2	9	135	3	12	82	52	8
2008	4	4	212	1	10	161	52	14
2009	9	11	177	1	15	141	42	10
2010	1	11	53	0	1	31	34	2
2011	3	23	204	1	19	158	53	7
2012	15	19	201	0	13	167	56	6
2013	3	33	161	2	22	57	118	3
2014	9	38	179	4	29	62	137	10
2015	4	26	246	1	36	81	163	18
2016	13	28	155	0	20	32	145	14
2017	3	20	133	7	6	34	116	9
Total	340	1020	3114	107	332	1584	2658	279

Table A2 Continued. Number of positive trips for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico.

Year	Mar-May	Jun-Aug	Sep-Nov	1-10	11-20	21-30	31-40	41-50	51-60	61+
1986	27	70	44	18	53	54	34	38	19	24
1987	43	49	31	13	43	65	43	47	54	52
1988	48	69	26	21	74	66	61	49	34	60
1989	21	40	19	14	59	64	60	44	44	67
1990	17	60	34	39	63	56	71	52	48	38
1991	24	54	15	26	61	84	67	71	39	45
1992	26	48	25	19	113	105	96	56	48	34
1993	24	48	18	20	87	91	86	57	31	39
1994	34	73	36	46	105	115	82	71	40	47
1995	41	103	12	50	102	109	73	103	33	23
1996	30	51	15	45	86	86	60	62	24	22
1997	27	56	22	53	131	95	63	46	20	37
1998	40	45	8	24	75	94	69	31	30	13
1999	20	23	0	32	51	56	54	24	25	26
2000	24	48	24	38	75	67	66	35	32	76
2001	27	37	18	80	131	114	82	33	26	50
2002	30	60	27	67	99	127	94	33	21	35
2003	31	37	31	43	110	133	102	45	26	33
2004	27	69	18	30	68	77	58	23	21	40
2005	56	64	12	29	75	86	84	32	18	35
2006	30	37	16	25	62	81	83	20	32	46
2007	50	82	6	19	56	112	98	19	30	43
2008	56	123	30	34	110	171	224	39	23	17
2009	34	109	45	27	149	182	250	40	30	38
2010	12	22	30	13	59	67	64	25	24	34
2011	33	154	36	10	53	92	152	39	31	61
2012	46	122	62	30	127	149	186	78	45	65
2013	24	118	52	38	148	212	209	64	67	88
2014	40	132	46	17	114	220	301	123	57	102
2015	61	156	45	16	125	228	304	80	95	109
2016	35	109	39	25	163	266	279	101	110	136
2017	33	80	34	39	148	208	226	81	66	102
Total	1071	2348	876	1000	2975	3732	3781	1661	1243	1637

Table A3. Proportion positive of trips for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico.

Year	CenSWTX	NWTX	ALNWFL	SWFL	0.5day	0.75day	Fullday	Dec-Feb
1986	0.742	0.650	0.308	0.350	0.167	0.500	0.617	0.375
1987	0.762	0.454	0.184	0.889	1.000	0.500	0.448	0.750
1988	0.632	0.487	0.190	0.846	0.125	0.240	0.470	0.455
1989	0.500	0.226	0.229	0.615	0.045	0.171	0.281	0.417
1990	0.500	0.360	0.211	0.281	0.353	0.233	0.339	0.429
1991	0.524	0.459	0.130	0.136	0.062	0.200	0.299	0.304
1992	0.500	0.359	0.137	0.286	0.077	0.122	0.272	0.471
1993	0.327	0.342	0.205	0.250	0.000	0.162	0.276	0.400
1994	0.246	0.262	0.315	0.800	0.318	0.179	0.346	0.375
1995	0.304	0.182	0.364	0.750	0.625	0.188	0.285	0.281
1996	0.231	0.291	0.245	0.462	0.127	0.245	0.292	0.214
1997	0.152	0.250	0.252	0.500	0.355	0.227	0.217	0.429
1998	0.300	0.407	0.279	0.000	0.077	0.304	0.314	0.308
1999	0.429	0.227	0.150	0.000	0.062	0.158	0.221	0.300
2000	0.240	0.324	0.206	0.250	0.048	0.156	0.312	0.167
2001	0.231	0.262	0.153	0.000	0.118	0.183	0.178	0.257
2002	0.143	0.326	0.270	0.500	0.059	0.300	0.268	0.400
2003	0.222	0.140	0.229	0.500	0.119	0.269	0.179	0.900
2004	0.318	0.391	0.383	0.000	0.167	0.364	0.439	0.467
2005	0.289	0.416	0.405	1.000	0.200	0.323	0.463	0.429
2006	0.125	0.152	0.271	0.000	0.043	0.262	0.302	0.231
2007	0.074	0.176	0.453	0.750	0.210	0.420	0.416	0.421
2008	0.222	0.400	0.362	0.333	0.143	0.397	0.366	0.538
2009	0.409	0.234	0.275	1.000	0.124	0.316	0.282	0.278
2010	0.077	0.229	0.237	0.000	0.091	0.204	0.276	0.286
2011	0.231	0.511	0.540	0.200	0.487	0.560	0.453	0.636
2012	0.429	0.345	0.344	0.000	0.260	0.365	0.326	0.240
2013	0.083	0.478	0.224	0.250	0.185	0.198	0.282	0.091
2014	0.391	0.520	0.216	0.667	0.197	0.170	0.324	0.170
2015	0.118	0.292	0.297	0.100	0.254	0.234	0.347	0.281
2016	0.565	0.326	0.161	0.000	0.133	0.082	0.269	0.187
2017	0.214	0.282	0.171	0.350	0.058	0.102	0.268	0.161
Total	0.331	0.362	0.261	0.372	0.197	0.262	0.321	0.323

Table A3 Continued. Proportion positive of trips with Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico.

Year	Mar-May	Jun-Aug	Sep-Nov	1-10	11-20	21-30	31-40	41-50	51-60	61+
1986	0.519	0.569	0.772	18	53	54	34	38	19	24
1987	0.489	0.366	0.463	13	43	65	43	47	54	52
1988	0.429	0.486	0.388	21	74	66	61	49	34	60
1989	0.259	0.263	0.200	14	59	64	60	44	44	67
1990	0.230	0.300	0.472	39	63	56	71	52	48	38
1991	0.329	0.254	0.179	26	61	84	67	71	39	45
1992	0.228	0.255	0.165	19	113	105	96	56	48	34
1993	0.247	0.250	0.196	20	87	91	86	57	31	39
1994	0.321	0.303	0.283	46	105	115	82	71	40	47
1995	0.318	0.387	0.182	50	102	109	73	103	33	23
1996	0.349	0.225	0.259	45	86	86	60	62	24	22
1997	0.270	0.230	0.234	53	131	95	63	46	20	37
1998	0.435	0.243	0.242	24	75	94	69	31	30	13
1999	0.175	0.177	0.000	32	51	56	54	24	25	26
2000	0.250	0.255	0.258	38	75	67	66	35	32	76
2001	0.170	0.151	0.234	80	131	114	82	33	26	50
2002	0.286	0.216	0.370	67	99	127	94	33	21	35
2003	0.231	0.145	0.333	43	110	133	102	45	26	33
2004	0.290	0.416	0.419	30	68	77	58	23	21	40
2005	0.441	0.370	0.316	29	75	86	84	32	18	35
2006	0.366	0.202	0.225	25	62	81	83	20	32	46
2007	0.472	0.406	0.120	19	56	112	98	19	30	43
2008	0.421	0.326	0.366	34	110	171	224	39	23	17
2009	0.239	0.263	0.366	27	149	182	250	40	30	38
2010	0.162	0.193	0.330	13	59	67	64	25	24	34
2011	0.500	0.527	0.522	10	53	92	152	39	31	61
2012	0.380	0.348	0.339	30	127	149	186	78	45	65
2013	0.167	0.250	0.292	38	148	212	209	64	67	88
2014	0.215	0.246	0.301	17	114	220	301	123	57	102
2015	0.276	0.314	0.257	16	125	228	304	80	95	109
2016	0.156	0.174	0.253	25	163	266	279	101	110	136
2017	0.164	0.172	0.228	39	148	208	226	81	66	102
Total	0.287	0.277	0.296	1	1	1	1	1	1	1

Appendix B

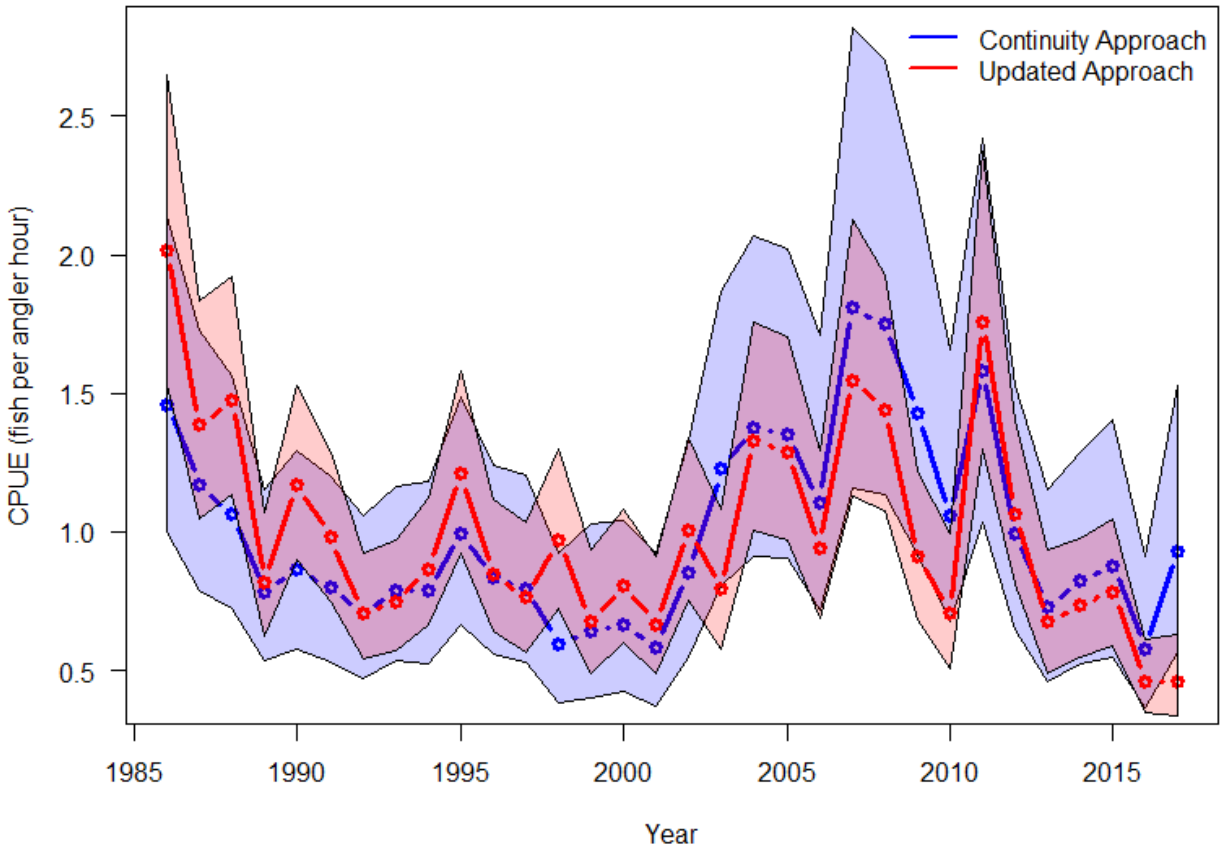


Figure B1. Comparison of standardized indices with 95% confidence intervals using the Headboat Continuity approach (see **Appendix C**) and the revised approach described herein for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico. The index was scaled to the mean value of the entire time series.

Appendix C: Headboat index using continuity approach

Abstract

The index in **Appendix C** uses data from the Southeast Region Headboat Survey (SRHS) and was developed following the methodology and approach used for previous SEDAR assessments.

Introduction and Headboat Data

See main document

Data Filtering

The following data preparation and filtering techniques were applied to the 1986-2017 SRHS dataset:
1. Observations were included from all states across the Gulf of Mexico.
2. Only half-day am, half-day pm, three-quarter day, and full-day trips were retained (86.5% of trips).
3. Trips with possible errors in effort information (two trips with 0 anglers) were excluded.
4. Trips during the closed season for shallow-water groupers were excluded (1.9% of trips).
5. The Stephens MacCall (2004) approach was used to restrict the dataset to those trips that likely encountered Scamp and Yellowmouth Grouper based on the trip's species composition.
6. Trips that reached bag limits for aggregate groupers were retained (0.037% of trips).

Species Association

An indirect method was necessary to infer targeting behavior of fishermen because no direct information was available. The Stephens and MacCall (2004) approach was used to restrict the dataset to anglers that likely encountered Scamp and Yellowmouth Grouper based on the trip's species composition. Trends in species associations over time were explored following previous research recommendations from other SEDARs because this approach assumes species associations are static over time. The validity of this assumption has been called into question because changes in management regulations may alter fisher behavior and targeting.

Standardization

See main document

Results and Discussion

U.S. Gulf of Mexico (Eastern and Western)

Species Associations - Stephens and MacCall (2004) Approach

The minimum difference between the predicted and the observed number of trips that reported Scamp and Yellowmouth Grouper occurred at the probability threshold of 0.23 (**Figure C1A**). Trips with a predicted probability that was greater than the critical threshold probability were identified as trips that targeted Scamp and Yellowmouth Grouper (**Figure C1B**). This method retained 7.1% of trips, and 30.8% of trips that reported Scamp and Yellowmouth Grouper. Prior

to trip selection, there were 235,290 trips and the proportion positive was 0.07, and after selection there were 16,807 trips and the proportion positive was 0.32. Given these diagnostics, although the proportion positive remained less than ideal (e.g., <50%), a standardized index of abundance was developed.

The Stephens and MacCall (2004) trip subsetting approach identified 45 species which were captured with Scamp and Yellowmouth Grouper and reflected either positive or negative associations (**Table C1**). For example, Vermilion Snapper, Rock Hind, Warsaw Grouper, Greater Amberjack, and Red Grouper are positively correlated to Scamp and Yellowmouth Grouper while Grass Porgy, White Grunt, Bank Sea Bass, Pinfish, and Crevalle Jack are negatively correlated.

Trends in Species Associations Over Time

The Stephens and MacCall (2004) approach was evaluated in five year intervals to determine how species associations changed as additional years of data were added to the analysis. Overall, the majority of species were retained across year intervals and displayed the same directional trend in association (**Figure C2**). Some exceptions to species retained were noted, as a few species were dropped when more recent years of data were included (**see Figure C3, panels with pink-purple-blue bars only**). In contrast, species such as hogfish (**Figure C3, panels with red-yellow-green bars only**) were retained when more recent years of data were included (**Figure C2**). Some associations strengthened as additional years of data were included as observed for Vermilion Snapper, Red Porgy, and Almaco Jack (**Figure C3**). In contrast, associations weakening over time were evident for Rock Hind, Red Grouper, Dolphin, and Red Snapper (**Figure C3**).

Overall, the statistics derived from the Stephens and MacCall (2004) approach were similar across time periods (**Figure C4**). The probability threshold remained between 0.21 and 0.23, roughly 30% of trips were retained, and the proportion positive went from about 7-9% before the Stephens and MacCall (2004) approach to approximately 30% after the Stephens and MacCall (2004) approach.

Variable Selection

The following factors were treated as fixed effects and were examined as possible influences on the proportion of positive trips and the catch rates on positive trips:

Name	DF	Details
Year	32	1986-2017
Season	4	Dec-Feb, Mar-May, Jun-Aug, Sep-Nov
Area	3	Cen SW TX, FL-AL-LA, NW TX
Trip Type*	3	Full day, Half day, Three quarter day
Anglers*	7	1-10, 11-20, 21-30, 41-50, 51-60, 61+

*Only explored as factors for modeling success because these factors were confounded with effort for the CPUE response variable in the lognormal model.

Annual Abundance Indices

Table C2 summarizes the standardized index, corresponding lower and upper confidence limits, coefficients of variation, and nominal CPUE. Final deviance tables are included in **Table C3**. The final models for the binomial and lognormal components were:

$$ProportionPositive = YEAR$$

$$ln(CPUE) = YEAR + AREA + SEASON + YEAR * AREA + YEAR * SEASON$$

Year was the only significant variable in the binomial model (**Table C3**) for the SEDAR68 index.

The standardized index, with 95% confidence intervals, is shown in **Figure C5**. The majority of nominal values fell within the 95% confidence intervals, with the exception of 1987, 1990, 1991, 1992, 1995, 1998, 2000, 2003 and 2017. Relative abundance remained below the time series mean early in the time series, peaked in 2007, and was at the lowest value in 2016 (**Figure C5**).

Diagnostics for each component of the GLM are provided in **Figure C6** and **Figure C7**. The overdispersion parameter for the binomial component was NA. The binomial model consistently estimated the proportion positive (**Figure C6A**). The proportion positive ranged from 0.21 to 0.54, and has generally remained between 0.27 and 0.36. Residual analysis of the binomial model indicated no obvious patterns in the residuals by year (**Figure C6B**).

The lognormal model results suggest a good fit to the data and indicated that the assumption of a lognormal distribution for positive catch was appropriate for the data (**Figure C7A-B**). Residual analysis of the lognormal model also indicated no obvious patterns in the residuals by year (**Figure C7C**), area (**Figure C7D**) or season (**Figure C7E**).

Comments on Adequacy for Assessment

The headboat index presented in **Appendix C** reflects the continuity approach to developing indices of abundance for Gulf stocks using the SHRS. While the analysis herein did not identify large differences in the results of the Stephens and MacCall (2004) approach, additional research is needed to explore alternative trip selection approaches which may be more appropriate for use.

References

Same as main document

Appendix C Tables

Table C1. Association coefficients by species for the U.S. Gulf of Mexico (Eastern and Western). Positive numbers indicate a positive correlation between a given species and Scamp and Yellowmouth Grouper.

Coefficient	Common Name	Scientific Name
1.108	Vermilion Snapper	*Rhomboplites aurorubens*
0.999	Rock Hind	*Epinephelus adscensionis*
0.872	Warsaw Grouper	*Epinephelus nigritus*
0.787	Greater Amberjack	*Seriola dumerili*
0.733	Red Grouper	*Epinephelus morio*
0.719	Red Porgy	*Pagrus pagrus*
0.682	Littlehead Porgy	*Calamus proridens*
0.617	Almaco Jack	*Seriola rivoliana*
0.467	Gag	*Mycteroperca microlepis*
0.442	Yellowtail Snapper	*Ocyurus chrysurus*
0.343	Black Grouper	*Mycteroperca bonaci*
0.323	Blackfin Tuna	*Thunnus atlanticus*
0.256	Jolthead Porgy	*Calamus bajonado*
0.252	Blue Runner	*Caranx crysos*
0.244	Knobbed Porgy	*Calamus nodosus*
0.235	Gray Triggerfish	*Balistes capriscus*
0.220	Gray Snapper	*Lutjanus griseus*
0.220	Bluefish	*Pomatomus saltatrix*
0.202	Blacktip Shark	*Carcharhinus limbatus*
0.180	Whitebone Porgy	*Calamus leucosteus*
0.170	Dolphin	*Coryphaena hippurus*
0.152	Pigfish	*Orthopristis chrysoptera*
0.149	King Mackerel	*Scomberomorus cavalla*
0.129	Little Tunny	*Euthynnus alletteratus*
0.122	Red Snapper	*Lutjanus campechanus*
0.116	Cobia	*Rachycentron canadum*
0.082	Lane Snapper	*Lutjanus synagris*
0.077	Banded Rudderfish	*Seriola zonata*
0.049	Hogfish	*Lachnolaimus maximus*
0.037	Great Barracuda	*Sphyraena barracuda*

Table C1 Continued. Association coefficients by species for the U.S. Gulf of Mexico (Eastern and Western). Positive numbers indicate a positive correlation between a given species and Scamp and Yellowmouth Grouper.

Coefficient	Common Name	Scientific Name
-0.011	Black Sea Bass	*Centropristis striata*
-0.035	Saucereye Porgy	*Calamus calamus*
-0.057	Sand Perch	*Diplectrum formosum*
-0.072	Atlantic Spadefish	*Chaetodipterus faber*
-0.094	Sand Seatrout	*Cynoscion arenarius*
-0.106	Rainbow Runner	*Elagatis bipinnulata*
-0.171	Spanish Mackerel	*Scomberomorus maculatus*
-0.213	Tomtate	*Haemulon aurolineatum*
-0.222	Gulf Flounder	*Paralichthys albigutta*
-0.228	Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*
-0.242	Crevalle Jack	*Caranx hippos*
-0.293	Pinfish	*Lagodon rhomboides*
-0.323	Bank Sea Bass	*Centropristis ocyurus*
-0.447	White Grunt	*Haemulon plumieri*
-0.645	Grass Porgy	*Calamus arctifrons*

Table C2. Numbers (N) of total and positive trips, proportion of positive trips (PPT), relative nominal CPUE, and standardized abundance index statistics for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico (Eastern and Western).

Year	N	Positive N	PPT	Relative Nominal CPUE	Relative Index	Lower 95% CI	Upper 95% CI	CV
1986	486	193	0.397	1.191	1.460	0.997	2.136	0.192
1987	497	163	0.328	0.723	1.168	0.789	1.728	0.198
1988	523	184	0.352	0.815	1.065	0.726	1.562	0.193
1989	659	184	0.279	0.600	0.784	0.533	1.152	0.194
1990	469	151	0.322	0.506	0.862	0.575	1.291	0.204
1991	468	120	0.256	0.490	0.798	0.532	1.198	0.205
1992	558	150	0.269	0.449	0.704	0.470	1.056	0.204
1993	610	176	0.289	0.594	0.788	0.534	1.164	0.197
1994	538	190	0.353	0.798	0.786	0.522	1.183	0.207
1995	529	173	0.327	0.655	0.993	0.664	1.486	0.203
1996	575	163	0.283	0.675	0.834	0.562	1.239	0.200
1997	650	162	0.249	0.540	0.797	0.528	1.202	0.208
1998	384	102	0.266	0.326	0.597	0.385	0.925	0.222
1999	261	57	0.218	0.482	0.641	0.400	1.026	0.239
2000	343	85	0.248	0.414	0.664	0.424	1.040	0.227
2001	528	110	0.208	0.635	0.584	0.369	0.925	0.233
2002	595	157	0.264	1.023	0.854	0.548	1.331	0.225
2003	730	199	0.273	2.478	1.226	0.804	1.869	0.213
2004	693	260	0.375	1.871	1.373	0.911	2.069	0.207
2005	796	289	0.363	1.618	1.354	0.908	2.021	0.202
2006	562	156	0.278	1.152	1.108	0.719	1.707	0.219
2007	474	208	0.439	2.025	1.808	1.159	2.818	0.225
2008	644	272	0.422	1.833	1.750	1.134	2.701	0.220
2009	680	247	0.363	1.613	1.430	0.920	2.224	0.223
2010	377	115	0.305	0.921	1.058	0.676	1.655	0.227
2011	521	281	0.539	2.067	1.581	1.033	2.419	0.215
2012	651	234	0.359	1.264	0.994	0.647	1.528	0.217
2013	522	146	0.280	0.750	0.729	0.462	1.151	0.231
2014	411	127	0.309	0.635	0.823	0.525	1.290	0.227
2015	404	150	0.371	0.799	0.879	0.550	1.405	0.238

Table C2. Numbers (N) of total and positive trips, proportion of positive trips (PPT), relative nominal CPUE, and standardized abundance index statistics for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico (Eastern and Western).

Year	N	Positive N	PPT	Relative Nominal CPUE	Relative Index	Lower 95% CI	Upper 95% CI	CV
2016	450	121	0.269	0.505	0.579	0.367	0.912	0.230
2017	232	65	0.280	1.553	0.931	0.567	1.526	0.251

Table C3. Final deviance tables for the regressions for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico (Eastern and Western). The table shows the order of the factors as they were sequentially added to each model. Fit diagnostics listed for each factor were the diagnostics from a model that included that factor and all of the factors listed above it in the tables below.

Factor	DF	Deviance	Residual DF	Residual Deviance	AIC	Deviance Reduced	Log likelihood	Likelihood Ratio Test
Binomial								
Null	1	21099	16819	21099	21099	-	-10549	-
Year	32	20748	16788	351	20748	1.48%	-10374	351
Lognormal								
Null	1	5498	5389	5498	15403	-	-7701	-
Year	32	4864	5358	633	14743	11.01%	-7371	659.8
Area	3	4599	5356	265	14441	5.42%	-7220	302.2
Season	4	4396	5353	203	14197	4.36%	-7098	243.4
Year*Area	61	4231	5293	164	13992	2.65%	-6996	205.4
Year*Season	93	4078	5201	152	13793	1.91%	-6896	198.4

Appendix C Figures

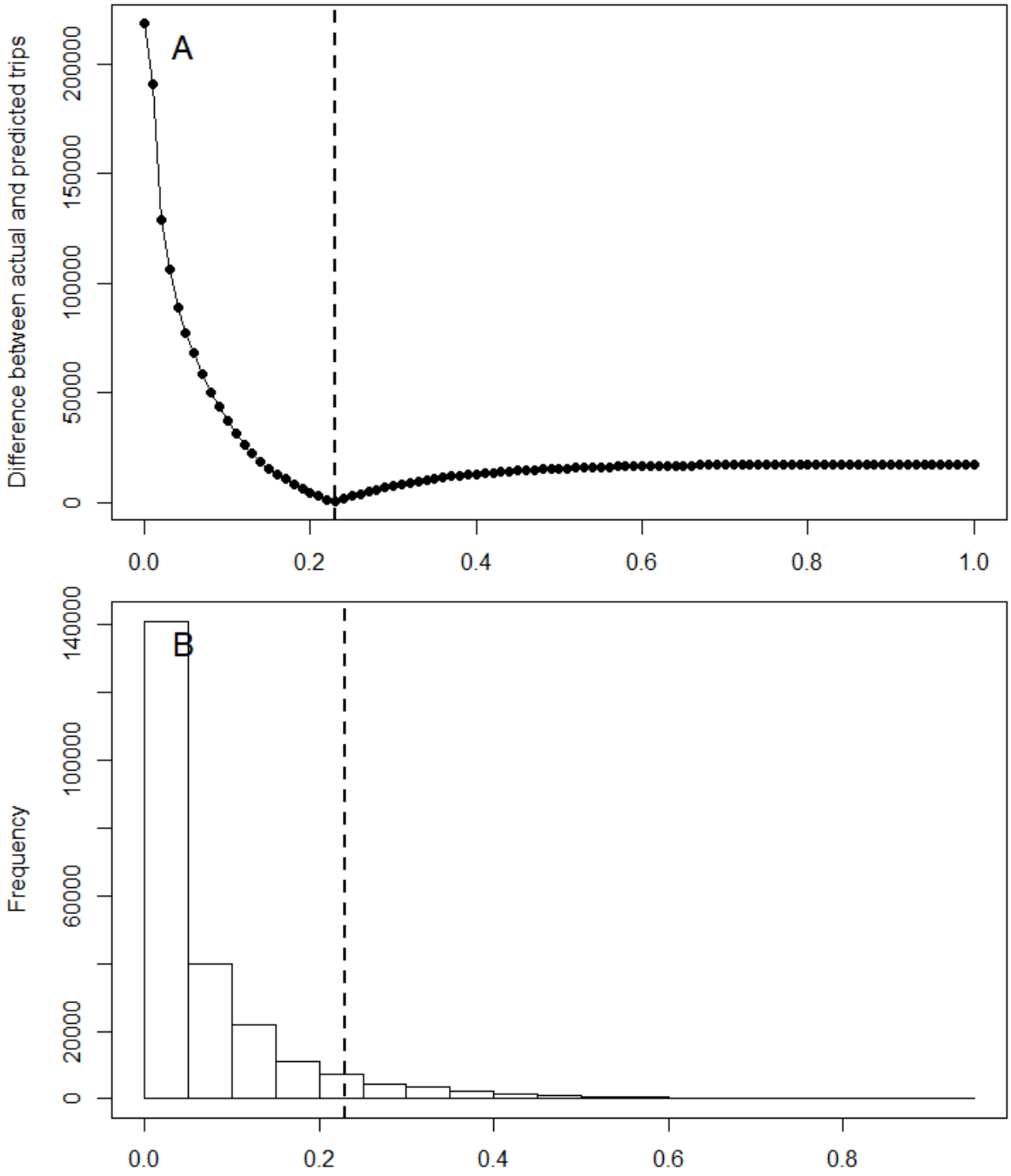


Figure C1. The difference between the number of records in the U.S. Gulf of Mexico (Eastern and Western) in which Scamp and Yellowmouth Grouper are observed and the number in which they are predicted to occur for each probability threshold (A). Histogram of probabilities generated by the species-based regression (B). The dashed vertical line indicates the critical value where false prediction is minimized.

Year Ranges

Associated Species	1986-1992	1986-1997	1986-2002	1986-2007	1986-2012	1986-2017
Almaco Jack	0.22	0.21	0.3	0.51	0.63	0.62
Atlantic Sharpnose Shark	0.26	0.04	-0.08	-0.12	-0.22	-0.23
Atlantic Spadefish	0.02	0	-0.1	-0.09	-0.05	-0.07
Banded Rudderfish	0.12	0.31	0.14	0.14	0.17	0.08
Bank Sea Bass	-0.39	-0.2	-0.23	-0.27	-0.41	-0.32
Bigeye	0.53	0.65				
Black Drum	-0.8	-0.72				
Black Grouper	0.04	0.17	0.26	0.33	0.27	0.34
Black Sea Bass	0.17	0.14	0.2	0.13	0.1	-0.01
Blackfin Tuna	0.15	0.26	0.27	0.27	0.26	0.32
Blacktip Shark	0.02	0.27	0.31	0.28	0.23	0.2
Blue Runner	0.14	0.14	0.14	0.15	0.11	0.25
Bluefish	0.32	0.34	0.29	0.25	0.21	0.22
Cobia	0.13	0.03	0.11	0.07	0.1	0.12
Crevalle Jack	-0.04	-0.15	-0.18	-0.23	-0.32	-0.24
Dolphin	0.35	0.31	0.28	0.25	0.19	0.17
French Grunt	0.16					
Gag	0.37	0.46	0.44	0.47	0.39	0.47
Grass Porgy	-1.06	-0.96	-0.8	-0.66	-0.8	-0.64
Gray Snapper	0.27	0.22	0.2	0.22	0.18	0.22
Gray Triggerfish	0.42	0.29	0.31	0.29	0.33	0.24
Great Barracuda	0.11		0.1	0.05	0.02	0.04
Greater Amberjack	0.74	0.68	0.74	0.77	0.8	0.79
Jolthead Porgy	-0.35	0.1	0.02	0.23	0.09	0.26
King Mackerel	0.03	0.05	0.07	0.05	0.09	0.15
Knobbed Porgy	0.24	0.25	0.23	0.23	0.2	0.24
Lane Snapper	-0.21	-0.05	0.05	0.07	0.1	0.08
efteye Flounder Family	-0.25					
Little Tunny	0.12	0.13	0.15	0.19	0.16	0.13
Littlehead Porgy	0.66	0.89	0.9	0.82	0.74	0.68
Pigfish	0.28	0.19	0.24	0.27	0.25	0.15
Pinfish	0.23	-0.03	-0.06	-0.18	-0.19	-0.29
Red Grouper	1.12	1	0.86	0.86	0.78	0.73
Red Porgy	0.07	0.43	0.51	0.61	0.75	0.72
Red Snapper	0.72	0.55	0.48	0.42	0.17	0.12
Rock Hind	1.21	1.03	1.07	1.01	0.98	1
Rock Sea Bass	-0.29					
Sand Perch	0.12	0.04	-0.04	-0.03	-0.08	-0.06
Sand Seatrout	-0.04	-0.29	-0.29	-0.15	-0.12	-0.09
Sandbar Shark	0.44	0.41	0.44	0.45	0.38	
Sheepshead Porgy	0.48	0.56				
Spanish Mackerel	-0.09	-0.04	-0.08	-0.05	-0.19	-0.17
Spottail Pinfish	0.62	0.72	0.8			
Squirrelfish	0.39	0.51	0.59			
Tomtate	-0.02	-0.19	-0.19	-0.2	-0.29	-0.21
Vermilion Snapper	0.88	0.94	0.91	0.9	0.99	1.11
Warsaw Grouper	0.81	0.89	0.94	0.87	0.84	0.87
White Grunt	-0.06	-0.27	-0.36	-0.3	-0.43	-0.45
Whitebone Porgy	0.27	0.18	0.17	0.14	0.11	0.18
Yellowtail Snapper	0.36	0.43	0.48	0.4	0.4	0.44
Saucereye Porgy		-0.13	0.06	0.05	0.01	-0.04
Summer Flounder		0.4	0.41			
Gulf Flounder			-0.44	-0.38	-0.28	-0.22
Rainbow Runner				-0.2	-0.21	-0.11
Hogfish					-0.12	0.05

Figure C2. Association coefficients by species across five-year intervals for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico (Eastern and Western). Positive numbers indicate a positive correlation between a given species and Scamp and Yellowmouth Grouper.

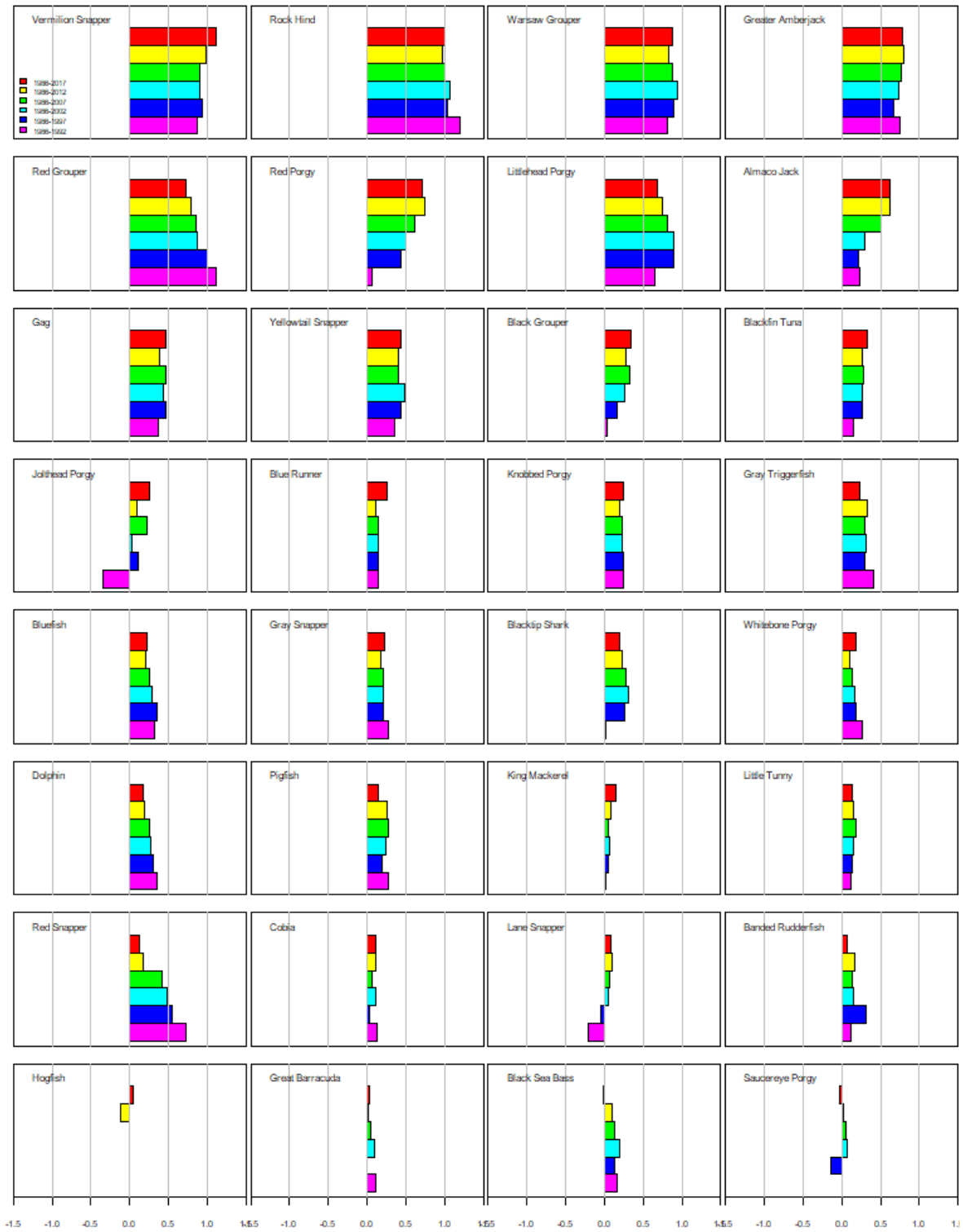


Figure C3. Comparison of association coefficients by species across five-year intervals for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico (Eastern and Western) from the shortest-earliest time series (pink, 1986-1992) through the longest-most recent time series (red, 1986-2017). Positive numbers indicate a positive correlation between a given species and Scamp and Yellowmouth Grouper.

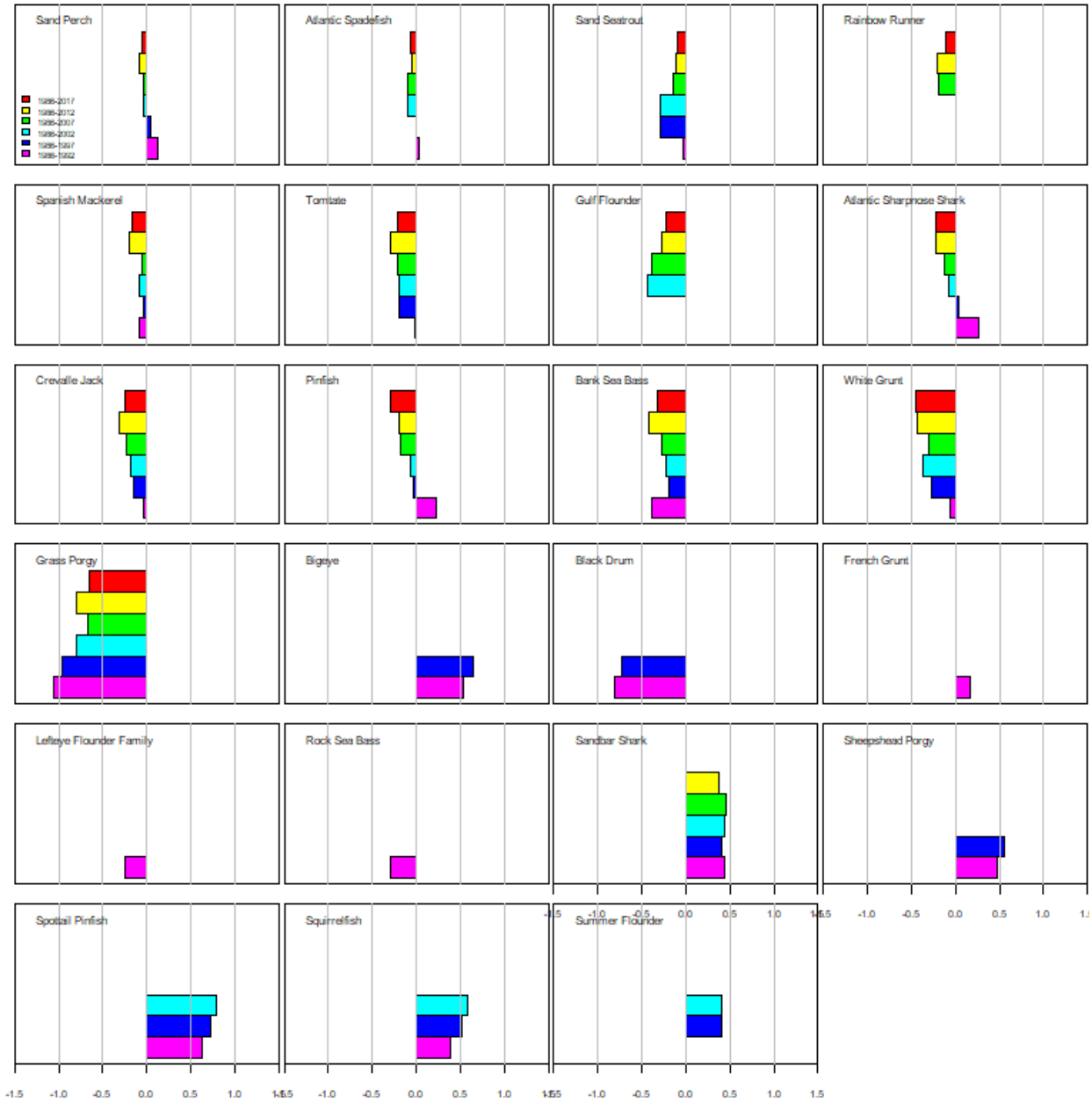


Figure C3 Continued. Comparison of association coefficients by species across five-year intervals for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico (Eastern and Western) from the shortest-earliest time series (pink, 1986-1992) through the longest-most recent time series (red, 1986-2017). Positive numbers indicate a positive correlation between a given species and Scamp and Yellowmouth Grouper.

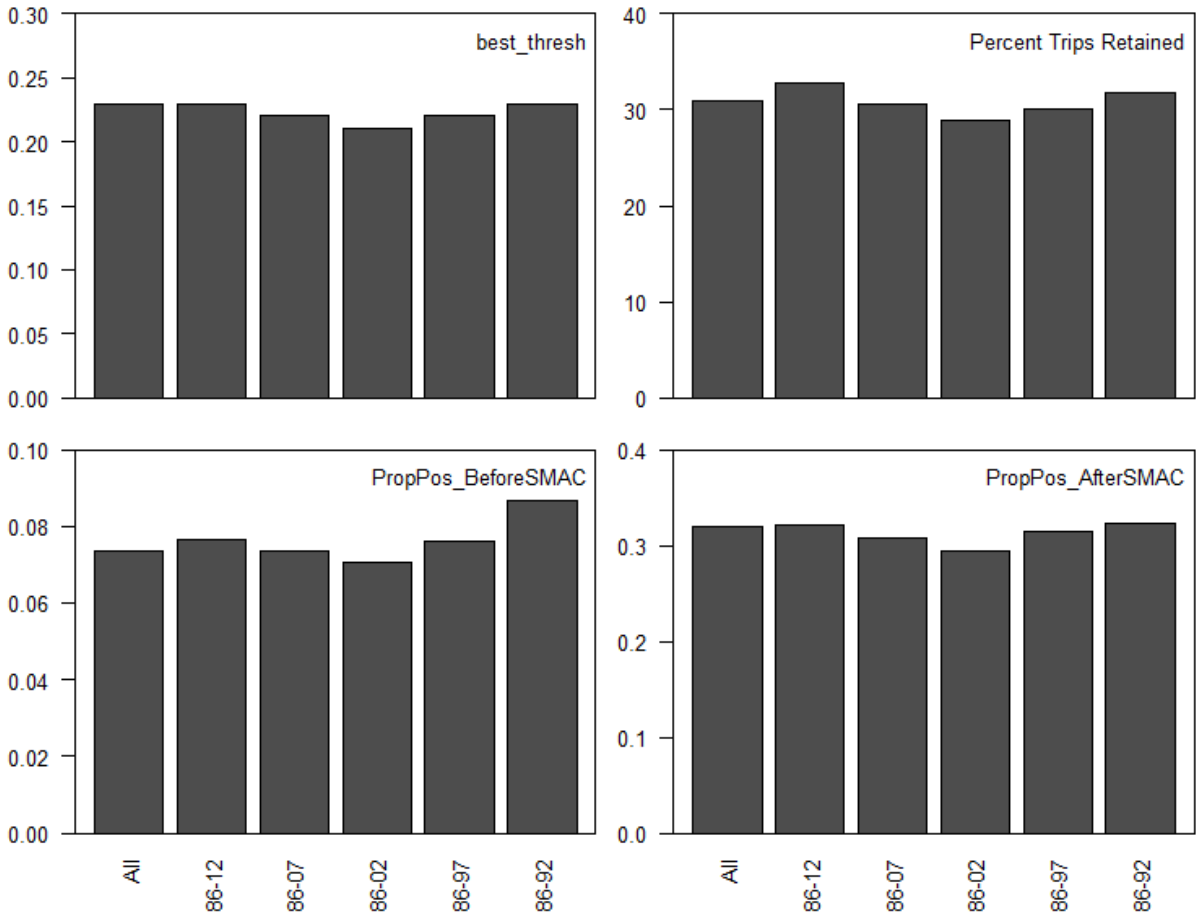


Figure C4. Stephens and MacCall (2004) statistics across five-year intervals for associations with Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico (Eastern and Western).

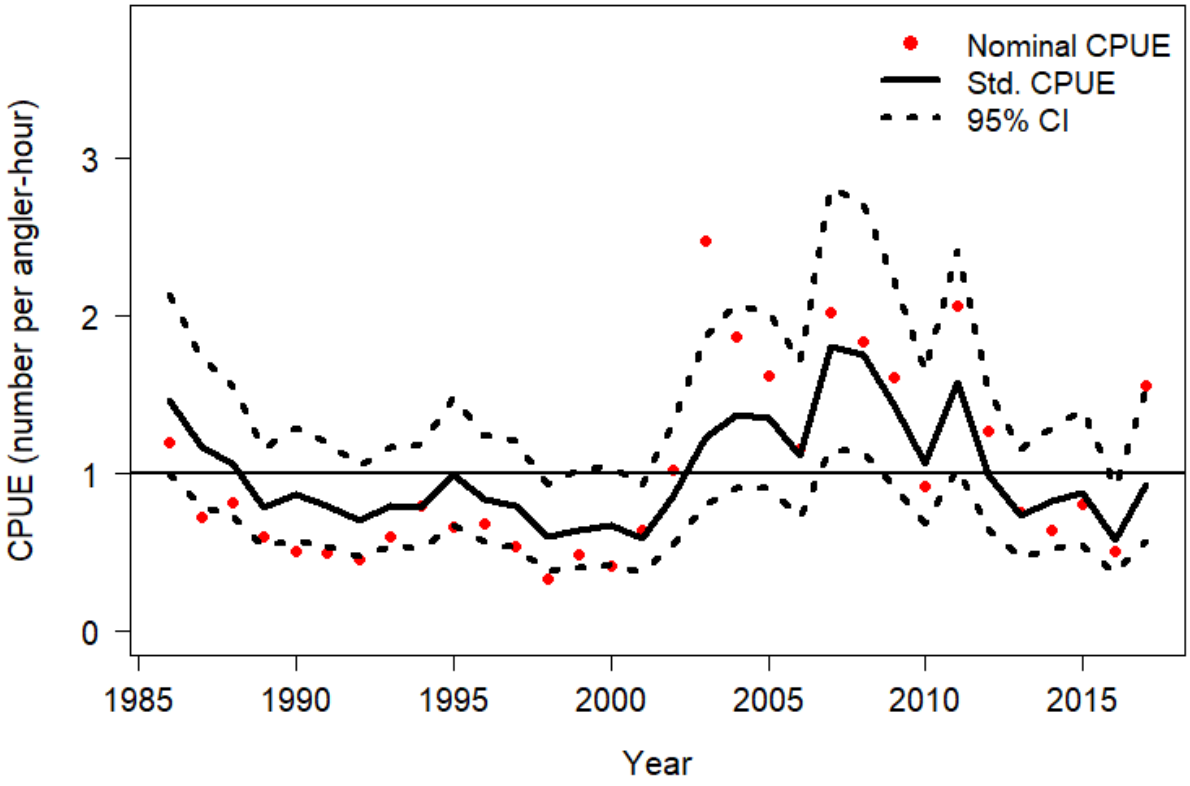


Figure C5. Standardized indices with 95% confidence intervals and nominal CPUE for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico (Eastern and Western).

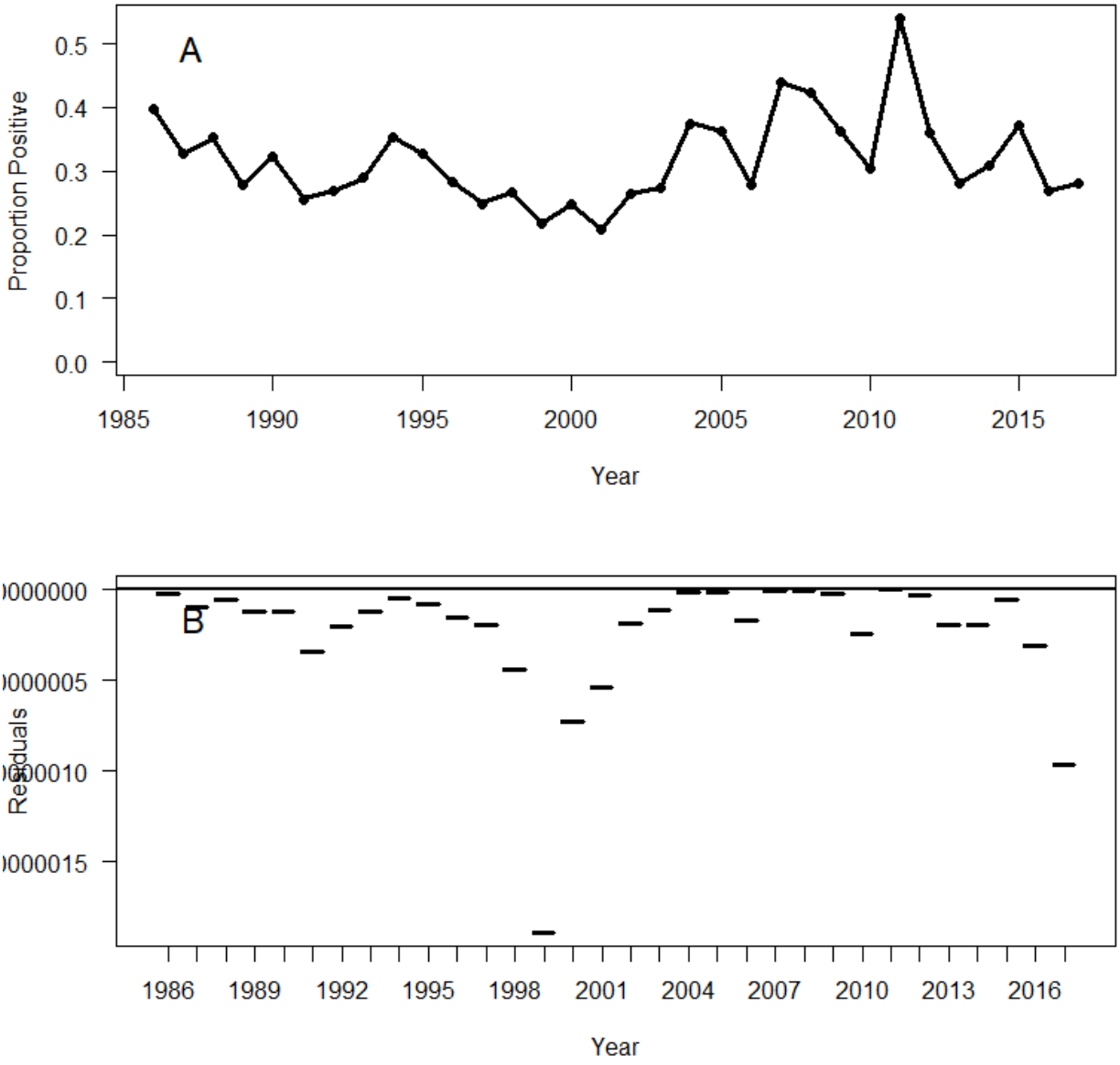


Figure C6. Diagnostic plots for the binomial model for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico (Eastern and Western). Shown here are the predicted (solid line) and observed proportion of positive trips by year (A) and the residuals from the binomial model by year (B).

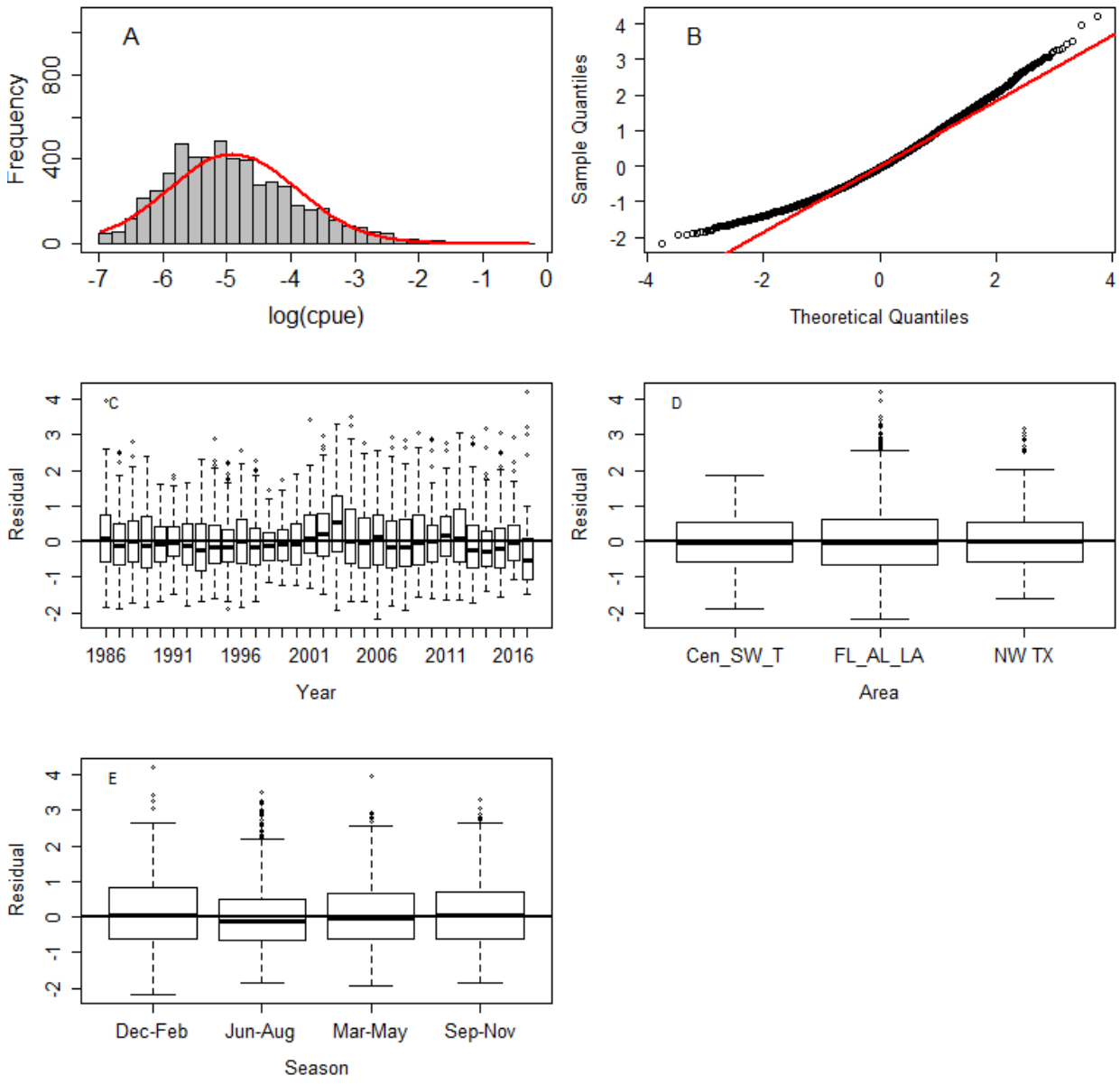


Figure C7. Diagnostic plots for the lognormal model of catch rates on positive trips for Scamp and Yellowmouth Grouper in the U.S. Gulf of Mexico (Eastern and Western). Shown here are the frequency distribution of catch rates (A), the cumulative normalized residuals (B), and the distribution of residuals by year (C), area (D) and season (E). The red lines represent the expected normal distribution.