Standardized Catch Per Unit Effort for Gulf of Mexico Red Grouper from the Southeast Region Headboat Survey

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SEDAR 88-WP-10

Standardized Catch Per Unit Effort for Gulf of Mexico Red Grouper from the Southeast Region Headboat Survey

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Introduction

The Southeast Region Headboat Survey (SRHS) collects catch, effort, and biological information from recreational headboats operating throughout the southeast region. As defined by SRHS, headboats are federally-permitted fishing vessels that charge anglers a per-head fee to fish for reef fish and coastal migratory pelagic species, typically over full day (8-10 hrs) or partial day trips (≈4 hrs) (Fitzpatrick et al. 2017). Conducted by the Beaufort Lab of the Southeast Fisheries Science Center (SEFSC), the SRHS was first implemented in the Carolinas in 1972 to provide estimates for the growing landings from this mode. The spatial extent of this survey has since grown, covering the entire South Atlantic by 1978 (NC through Monroe county, FL) and Gulf of Mexico by 1986 (South Padre Island, TX to Naples, FL) (SEDAR 79-DW-06).

The analysis described in this working paper is aimed at constructing an index of abundance for Gulf of Mexico red grouper from SRHS headboat data. This analysis relies on industry-reported SRHS logbooks that provide trip-level data on species catch, effort, and associated catch rates. Information collected by these logbooks include vessel identification, a single fishing area for the entire trip (Figure 1), landing location and date, number of anglers, trip duration (in hours) and/or trip type (e.g., half day vs. full day).

Because the SRHS was designed to be a census, the catch records contained in these logbooks comprise the majority of headboat fishing activity across the southeast region, with compliance being near 100 percent since permits became tied to reporting requirements in 2008. Logbook catch records were submitted via paper forms until 2013, when the survey switched to electronic reporting. During this time, paper forms were largely state-specific as space constraints on the form required limiting the listed species to predominant taxa, which varied across the region. Logbook forms also tended to change over time, with most state-specific forms tending to add more species throughout the early years of the survey (SEDAR 79-DW-06, Appendix A in Fitzpatrick et al. 2017).

Methods

Catch per unit effort (CPUE) of Gulf of Mexico red grouper by headboat anglers was calculated on an individual trip basis from SRHS logbook data. The CPUE for each trip was estimated as the number of red grouper landed on a trip divided by the fishing effort, where effort was the product of the number of anglers and total hours fished. As an estimate of total hours fished, we assumed a full-day of SRHS headboat fishing (as recorded in the trip type field) constitutes 10 hours, with all other trip types scaled proportionally (e.g., half-day = 5 hours). This decision to translate hours fished from trip type is based on the need for consistency in CPUE data, and considered a better alternative to using the trip length field (in hours) which is only available in SRHS logbook data after the switch to electronic reporting (2013+).

Data Filtering

The following data preparation and filtering techniques are routinely applied to SRHS logbook data when constructing abundance indices:

- Vessels that had fewer than 30 trips in the logbook database were excluded. Logbooks submitted by vessels that participated infrequently in the fishery are likely to be less representative of true fishery trends. Even if a vessel fished infrequently for one year, the number of trips should be greater than 30.

- Trips with 6 or fewer anglers were excluded. 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.
- Trips with possible data errors were excluded, including trips with multiple catch records for a single species, potentially duplicated effort information, that report zero effort (i.e., number of anglers = 0), or with catch and effort values outside the 99.9% confidence intervals of the observed ranges.

Beyond these standard filters, SRHS indices for SEDAR 88 Gulf of Mexico red grouper required additional decisions. In agreement with procedures followed in past SEDAR stock assessments for this species (SEDAR 61):

- Observations in the Gulf of Mexico were limited to two regions: southwest Florida (area 21) and northwest Florida and Alabama (area 23) (Figure 1).
- Observations were retained from half-day, three-quarter day, and full-day trips.
- Trips during the closed season for red grouper were excluded.
- Trips that reached bag limits for red grouper and aggregate groupers were retained.

Novel filters, to those applied in past assessments for this species (SEDAR 61), were also applied in preparing SRHS logbook data for index construction in SEDAR 88:

- Records after 2007 were excluded. This year was largely chosen due to the perceived effect of circle hooks on the catchability of red grouper, the use of which was mandated by Reef Fish Amendment 27 in 2008. A similar filter was applied in SEDAR 42, for which the NMFS Bottom Longline index excluded years corresponding to fishing with J-hooks, after which the change to circle hooks caused red grouper catch to increase "by an order of magnitude" (SEDAR 2015). Coupled with the bag limits on red grouper at this time, this change in catchability is seen in the discard rates of recreational anglers, which substantially increased in 2008 (Figure 7 in SEDAR 88-WP-02, Figure 1 in SEDAR 88-WP-05). Note that this truncation also controls for any possible effects from subsequent changes in management after 2007 (e.g., quotas, size and bag limits, spatial or seasonal closures), the frequency of which has increased over the more recent decade(s) and casts doubt as to whether fishery-dependent datasets are still adequately tracking stock abundance. Taking a precautionary approach (SEDAR 82-DW-06) for the SEDAR 88 SRHS index, the noted changes in catchability of red grouper, behavior of recreational anglers (i.e., discard rates), and recent frequency of new management regulations warranted limiting SRHS logbook data to the years 1986-2007. This investigation, and the associated filter, was conducted to address the SEDAR 61 recommendation to investigate whether the assumptions required to construct fishery-dependent CPUE indices are appropriate across the full time series, with respect to the SRHS index.

Subsetting Trips – Species Associations

Because fishery-dependent data are not collected under a formal (e.g., stratified random) sampling design, the sampling intensity in any given area can vary substantially between years. In this, fishery-dependent data, by itself, may be insufficient to identify suitable habitat for the species-of-interest. In other cases, the data may allow for identification of habitat, but the associated sampling may be inconsistent or not reported at a fine enough resolution for the required analysis. Because such habitat designations are needed in controlling for absence (i.e., fish not available to be caught) when predicting the relative presence of species in trip-level catches, the construction of fishery-dependent indices requires some method to quantify effective effort and distinguish trips where a given species was present but not caught (i.e., fishing in suitable habitat) vs. trips where that species was not present (which are excluded from the analysis). The trip selection approach applied for the SEDAR 88 SRHS index was the Stephens and MacCall (2004) method, which uses multiple logistic regression to estimate the probability that the focal species was caught on a given trip based on the relative association of that focal species with any other species caught on that trip.

- The Stephen and MacCall approach was applied separately for the two headboat areas retained in this analysis due to suspected differences in species compositions between regions. Such differences have been suggested in other areas of the Gulf of Mexico, linked to differences in habitat types between the eastern and western Gulf of Mexico that are characterized by hard bottom habitats and less hard structure respectively (SEDAR 2011). These region-specific association parameters are new to red grouper stock assessments but have been researched and applied in past SEDARs (e.g., SEDAR 68-DW-02, SEDAR 68-DW-18).
- In applying the Stephens and MacCall (2004) approach, the species considered were limited to reef fish species that were consistently identified on SRHS logbook forms across all years (Table 1 in SEDAR 68-DW-18). This filter was applied to ensure decisions on trip selection were limited to those species that had a relatively equal chance of being reported on SRHS logbooks, given they were caught. This filter is new to red grouper stock assessments but has been researched and applied in past SEDARs (e.g., SEDAR 68-DW-02, SEDAR 68-DW-18).
- An additional (species) filter was also considered to remove any species for which the length of its fishing season has changed over time. This filter was not ultimately pursued in SEDAR 88 as most of these management changes have occurred over the last decade(s) and so were largely accounted for by truncating our index at a terminal year of 2007.

Standardization

A two-stage delta-lognormal generalized linear model (GLM; Lo et al. 1992) was used to standardize catch rates from SRHS logbooks for any variability or non-randomness not caused by inter-annual fluctuations in stock abundance. This method combines two separate generalized linear models (GLMs), one to describe the relative presence/absence of the focal species across all trips (i.e., proportion of headboat trips that caught at least one fish) and one to describe the catch rates of the focal species in those (positive) trips that successfully caught the species. In the first step, the proportion positive is modeled using a logit regression assuming a binomial error distribution of the response variable. In the second step, the logarithm of CPUE on positive trips was used as the response variable assuming a normal error distribution and an identity link function. The response variable for the lognormal model was calculated as:

$$ln(CPUE) = ln(Catch / [anglers \times hours\ fished])$$

A forward stepwise regression approach was applied to build both of these models, using the GENMOD procedure in SAS. In this procedure, factors were iteratively added to the base model and tested for retention (one at a time) based on the resultant 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 with significance evaluated between nested models using the likelihood ratio test. These interactions were screened and only retained if the model improvement was significant ($p< 0.0001$). Any YEAR*FACTOR interaction terms retained in model building were treated as random effects.

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).

Once constructed, these two models were then combined to provide a single standardized index of abundance for SEDAR 88 Gulf of Mexico red grouper. Predictions from the binomial (proportion positive) and lognormal (mean CPUE from positive trips) models were calculated from the estimated year effects and multiplied together to produce annual estimates of catch rate. This final delta-lognormal model was fit using the SAS GLIMMIX macro (glmm800MaOB.sas: Russ Wolfinger, SAS Institute) and the PROC MIXED procedure in SAS, which follows the procedures of Lo et al. (1992).

Results and Discussion

Subsetting Trips – Species Associations - Central Gulf of Mexico

The minimum difference between the predicted and the observed number of trips that reported red grouper occurred at the probability threshold of 0.31 (Figure 2A-A). Predicted trips showed a general increasing trend throughout the time series, were overestimated in the middle of the time series and underestimated at the end of the timeseries (Figure 2A-B). Nominal CPUE was relatively similar before and after applying the Stephens and MacCall (2004) approach, with the exception of the early- and mid- 2000s wherein nominal catch rates were marginally higher and lower in the subsetted datasets respectively (Figure 2A-C). The Stephens and MacCall (2004) trip subsetting approach identified 24 reef fish species that were positively/negatively associated with red grouper in the central Gulf of Mexico: gag, red porgy, white grunt, and scamp were positively correlated to red grouper whereas bank sea bass, bigeye, tomtate, and blue runner were negatively correlated (Figure 3).

Subsetting Trips – Species Associations - Eastern Gulf of Mexico

The minimum difference between the predicted and the observed number of trips that reported red grouper occurred at the probability threshold of 0.35 (Figure 2B-A). Predicted trips showed a general decreasing trend throughout the time series, with slight overestimation in the middle of the time series and underestimation at the end of the timeseries (Figure 2B-B). Nominal CPUE was relatively similar before and after applying the Stephens and MacCall (2004) approach, as seen throughout the entire time series (Figure 2B-C). The Stephens and MacCall (2004) trip subsetting approach identified 22 reef fish species that were positively/negatively associated with red grouper in the eastern Gulf of Mexico: scamp, vermilion snapper, gag, and lane snapper were positively correlated to red grouper whereas white grunt, tomtate, rainbow runner, and gray triggerfish were negatively correlated (Figure 3).

Variable Selection

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

Name	DF	Details
Year	22	1986-2007
Area	2	NW FL & AL , SW FL
Season	4	1 (Dec-Feb), 1 (Mar-May), 3 (Jun-Aug), 4 (Sep-Nov)
Trip Type*	3	Full day , Half day , Three quarter day
Anglers*	7	1-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61+

*Only explored as factors for modeling success in the binomial model as these (effort) variables are confounded with the CPUE response variable in the lognormal model.

Annual Abundance Indices

Deviance tables used to select variables in model building are provided in Table 1. The final models for the binomial (i.e., proportion positive) and lognormal (catch rate of positive trips) models were:

$ProportionPositive$ = YEAR + TRIPTYPE + AREA + SEASON + YEAR*AREA + YEAR*TRIPTYPE

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

Note that in contrast to SEDAR 61, a fixed SEASON effect was found to be a significant predictor of proportion positive in SEDAR 88. Diagnostics for each of these GLMs are provided in Figures 4 and 5, respectively. Summaries of strata-specific sample sizes used in GLM fitting are provided as the total number of SRHS trips after data filtering and trip selection, the associated number of positive trips, and proportion positive (Appendix A).

The final standardized index for SEDAR 88 Gulf of Mexico red grouper, with 95% confidence intervals, is provided in Table 2 and Figure 6. Nominal CPUE values fell within the 95% confidence intervals of the standardized index in all years of the time series. In the standardized index, relative abundance was largely above the time series mean over the first few years (1986-1989) and last few years (2003-2007). Note that over these last few years, the index also predicts a relative drop in red grouper abundance in the terminal years (2006-2007) as compared to the peaks in 2004-2005. This index largely agrees with that derived in SEDAR 61 (Figure 6).

Comments on Adequacy for Assessment

The SRHS abundance index for SEDAR 88 Gulf of Mexico red grouper appears adequate for the time period over which it's being provided (1986-2007). It was constructed stepwise, starting with a continuity that used the same assumptions applied in SEDAR 61 (Appendix B) but into which methodological improvements have been incorporated (i.e., truncation of terminal year, application of species filter, region-specific estimates of Stephens and MacCall species-association parameters). The SRHS index was used in both SEDAR 42 and 61 because it provides one of the longest time series available and has relatively widespread spatial coverage as compared to other regional indices.

Additionally, the behavior of recreational anglers during the time period covered by the SEDAR 88 SRHS index appears relatively consistent (i.e., discard rates, Figure 7 in SEDAR 88-WP-02) with relatively few management regulations being implemented, notable exceptions including:

- a 20" (federal) size limit and 5-grouper aggregate bag limit set in 1990
- species-specific bag limits that were implemented in 2004 (2 red grouper) and modified in 2005 (1 red grouper)

No appreciable effects of the 2004 and 2005 bag limits were apparent from the data, but the 1990 size limit looks to have caused reductions in both SRHS landings rates (CPUE) and the percent of positive SRHS trips with red grouper landings (Figure 7). A similar change is noted in general recreational fisheries, with both absolute discards and associated discard rates increasing at this time (SEDAR 88-WP-02). Taken together, the 20" size limit established in 1990 appears to have changed the overall retention of red grouper by recreational anglers in the Gulf of Mexico (i.e., reduced landings and increased discards).

Considerable discussion was made with regards to accounting for the effect of this 1990 management change. Truncation of the SEDAR 88 SRHS abundance index (i.e., exclusion of 1986-1989) was not pursued as no alternative index is available for this historical period, and so may impede building the SEDAR 88 assessment model. We also considered accounting for this management change within index standardization, for example using time blocks to account for changes in retention. Indeed, time blocks were also used in SEDAR 61, which estimated separate SRHS retention parameters for 1986-1989 and 1990+ that were incorporated into the final fit to the SRHS index in that SEDAR. Given the SEDAR 88 model is likely to be built from the SEDAR 61 model, and that this model is already configured to account for the change in red grouper retention in 1990, this effect is not being accounted for in the SRHS abundance index with the assumption that it will be accounted for within the assessment model. This assumption has been communicated to the lead analyst for the SEDAR 88 stock assessment.

Despite the general support on the adequacy of this index, there is also evidence to suggest that the species associations being estimated in Stephens and MacCall (2004) trip selection are not static over the modeled time period, an underlying assumption of the approach. This was evaluated in an exploratory data analysis, whereby Stephens and MacCall trip selection was conducted on binned subsets of the full SRHS logbook dataset (e.g., annual, 3-

year, and 5-year time blocks). There are a number of mechanisms by which the interaction between two species can change over time (e.g., variability in relative abundance, shifts in spatial distributions, behavioral changes related to prey availability and/or predator avoidance) and so it is unclear how likely this assumption is to hold in real marine ecosystems over periods that can span decades. The estimation of such interactions is further complicated in fishery-dependent datasets, within which catch compositions can also be influenced by any changes to the fishery (e.g., management regulations). Therefore, alternative (fishery-independent) indices should probably be favored to the SRHS (fishery-dependent) index in assessments and/or for time periods wherein such indices are available. For assessments and/or time periods where alternative indices are unavailable, alternative approaches to Stephens and MacCall trip selection may need to be identified and evaluated to ensure negative trips (i.e., with no red grouper catch) are being properly distinguished between trips where the focal species was not present vs. those where they were present but not caught.

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Table 1. Deviance tables for the generalized linear models for red grouper in the 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 other factors listed above it.

Binomial

Factor	DF	Deviance	Residual Df	Residual Deviance	AIC	% Deviance Reduced	log likelihood	Likelihood Ratio Test
Null	1	40,017.2	29,064	40,017.2	40,019		-20,009	
Year	22	37,778.1	29,043	2,239.1	37,824	0.0553	-18,889	2239.2
Trip Type	3	35,765.4	29,041	2,012.7	35,817	0.0532	-17,883	2012.6
Area	2	35,274.1	29,040	491.3	35,330	0.0137	-17,637	491.2
Season	4	34,903.8	29,037	370.3	34,968	0.0104	-17,452	370.4
Year * Area	22	33,960.8	29,016	943.0	34,069	0.0263	-16,980	943.0
Year * Trip Type	43	33,404.2	28,974	556.6	33,598	0.0150	-16,702	556.6

Lognormal

Factor	DF	Deviance	Residual Df	Residual Deviance	AIC	% Deviance Reduced	log likelihood	Likelihood Ratio Test
Null	1	20,655.6	15,945	20,655.6	49,381		-24,690	
Year	22	17,642.4	15,924	3,013.2	46,911	0.1448	-23,432	2,514.4
Season	4	17,314.0	15,921	328.4	46,619	0.0184	-23,283	299.4
Area	2	17,108.0	15,920	206.0	46,432	0.0118	-23,187	191.0
Year*Area	22	16,161.3	15,899	946.7	45,569	0.0541	-22,733	907.8
Year*Season	64	15,669.8	15,836	491.5	45,204	0.0266	-22,487	492.4

Table 2. Number of total (N) and positive trips (Positive N), proportion of positive trips (PPT), relative nominal CPUE, and standardized abundance index statistics for Red Grouper in the US Gulf of Mexico.

Year	N	Positive N	PPT	Relative Nominal CPUE	Relative Index	Lower 95% CI	Upper 95% CI	CV
1986	1407	937	0.666	1.7948	0.9810	0.2815	3.4186	0.6902
1987	1233	946	0.767	2.8067	1.8565	0.5958	5.7844	0.6174
1988	1286	999	0.777	3.0255	1.4201	0.4687	4.3029	0.5997
1989	1434	1063	0.741	3.3641	1.6683	0.5227	5.3249	0.6328
1990	2086	1192	0.571	1.2772	0.6881	0.1824	2.5954	0.7441
1991	1876	1061	0.566	0.8426	0.5189	0.1321	2.0388	0.7727
1992	1982	1060	0.535	0.7813	0.3952	0.0972	1.6073	0.7973
1993	1884	849	0.451	0.5369	0.6036	0.1621	2.2481	0.7353
1994	1849	849	0.459	0.5326	0.6003	0.1644	2.1924	0.7219
1995	1234	607	0.492	0.6185	0.7375	0.2064	2.6348	0.7070
1996	1384	502	0.363	0.5960	0.6357	0.1672	2.4176	0.7498
1997	1430	468	0.327	0.2656	0.4004	0.0995	1.6118	0.7899
1998	1313	508	0.387	0.3303	0.5221	0.1357	2.0094	0.7581
1999	943	385	0.408	0.2677	0.5301	0.1405	2.0006	0.7445
2000	948	413	0.436	0.4725	0.4031	0.0989	1.6436	0.7991
2001	916	435	0.475	0.4658	0.8040	0.2260	2.8603	0.7041
2002	778	378	0.486	0.4138	0.8609	0.2501	2.9635	0.6821
2003	1154	731	0.633	0.5973	1.3246	0.4512	3.8886	0.5800
2004	1089	805	0.739	0.9949	2.4990	0.9734	6.4158	0.4989
2005	1383	1035	0.748	1.1443	2.5093	0.9913	6.3523	0.4906

2006	741	345	0.466	0.3998	0.9028	0.2664	3.0597	0.6718
2007	715	378	0.529	0.4719	1.1385	0.3619	3.5816	0.6235

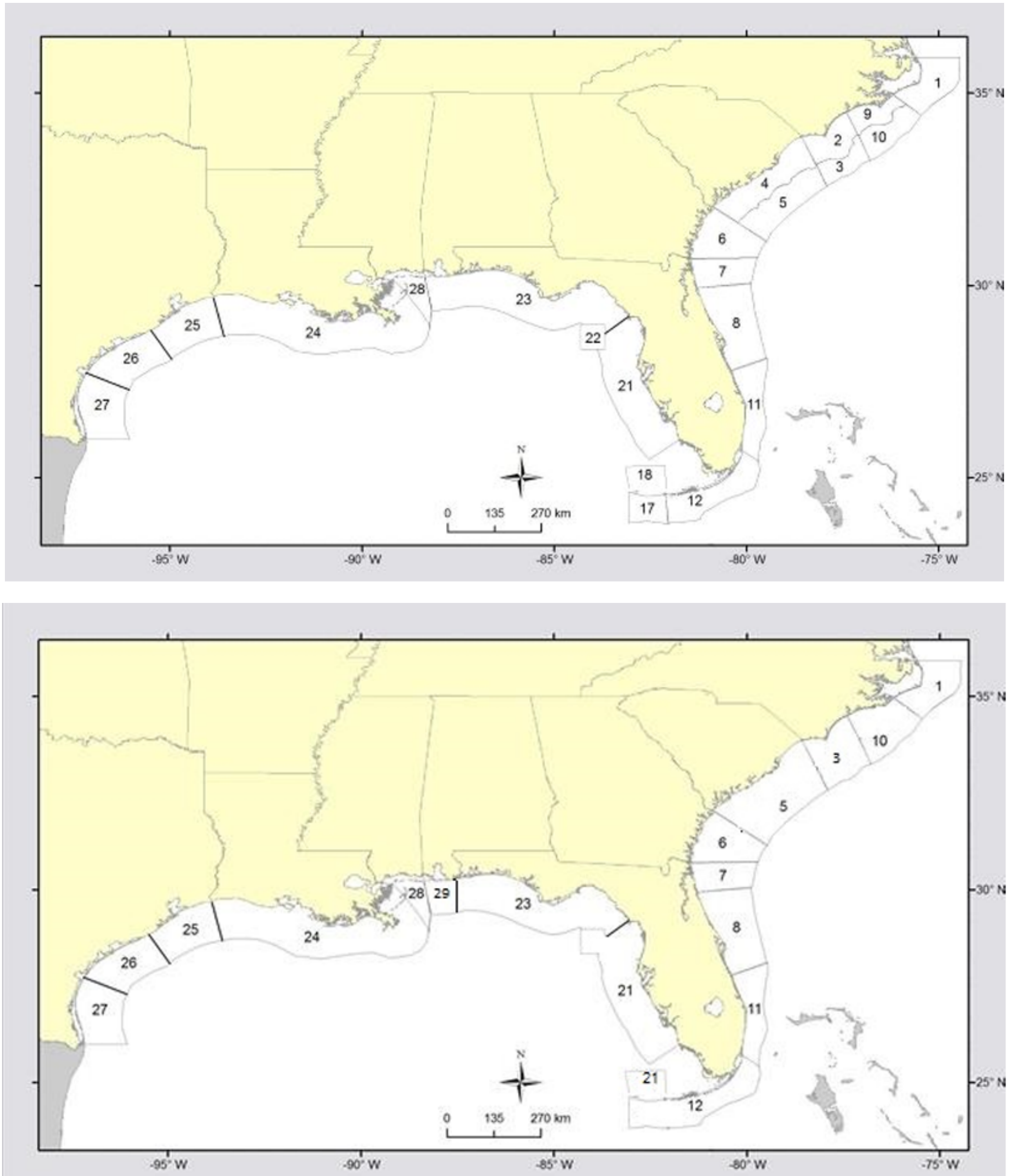


Figure 1. Headboat sampling areas as 10’ x 10’ rectangles of latitude and longitude for years prior to 2013 (top) and from 2013 to present (bottom).

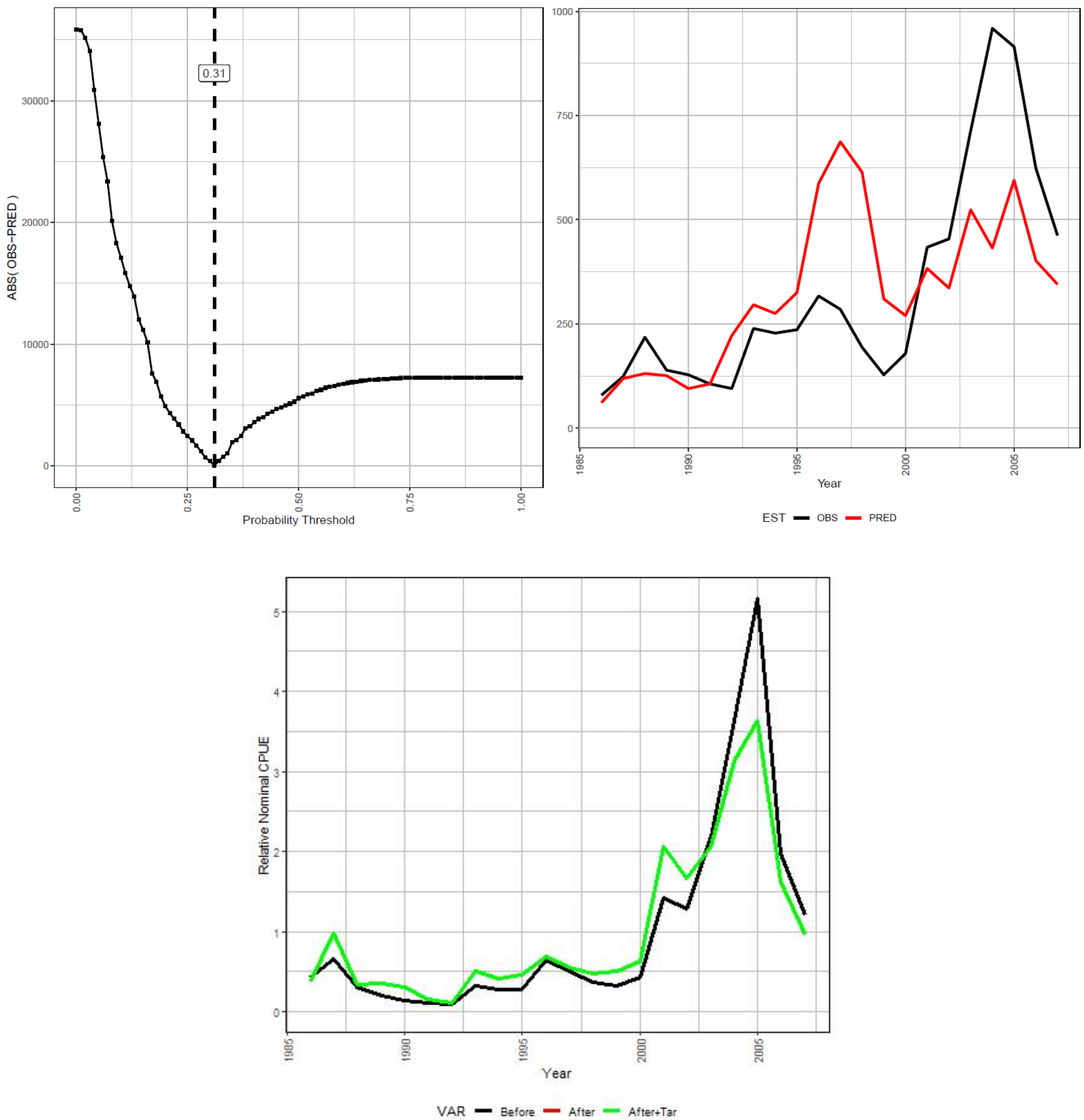


Figure 2A. Diagnostic plots for Stephens and MacCall (2004) trip selection for the central Gulf of Mexico (headboat area 23). (A) The difference between the number of records in which Red Grouper are observed and the number in which they are predicted to occur for each probability threshold; (B) the number of actual and predicted trips; and (C) Nominal CPUE before (“Before SM”) and after (“After SM”) Stephens and MacCall (2004) trip selection. The dashed vertical line indicates the critical value where false prediction is minimized.

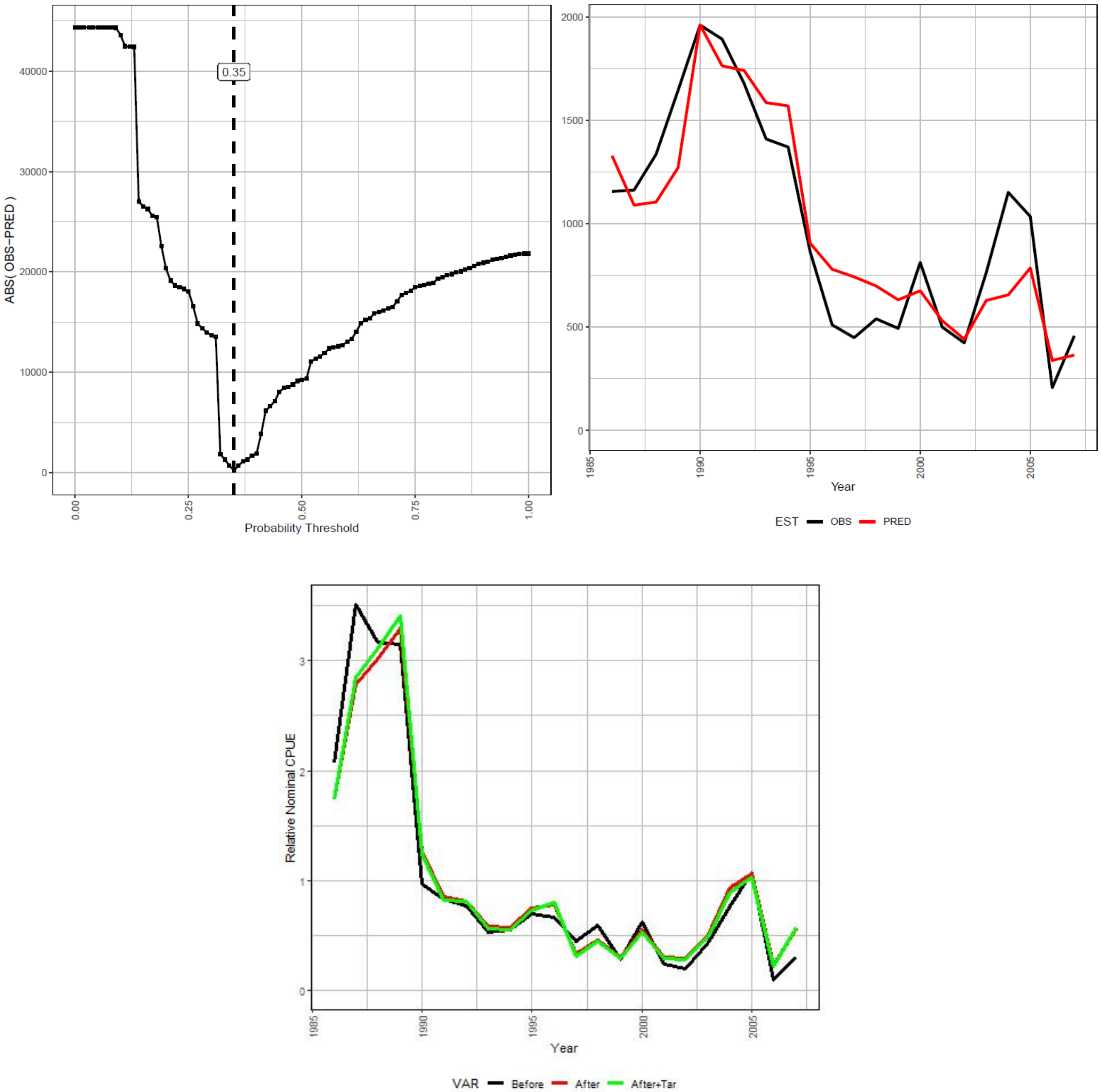


Figure 2B. Diagnostic plots for Stephens and MacCall (2004) trip selection for the eastern Gulf of Mexico (headboat area 21). (A) The difference between the number of records in which Red Grouper are observed and the number in which they are predicted to occur for each probability threshold; (B) the number of actual and predicted trips; and (C) Nominal CPUE before ("Before SM") and after ("After SM") Stephens and MacCall (2004) trip selection. The dashed vertical line indicates the critical value where false prediction is minimized.

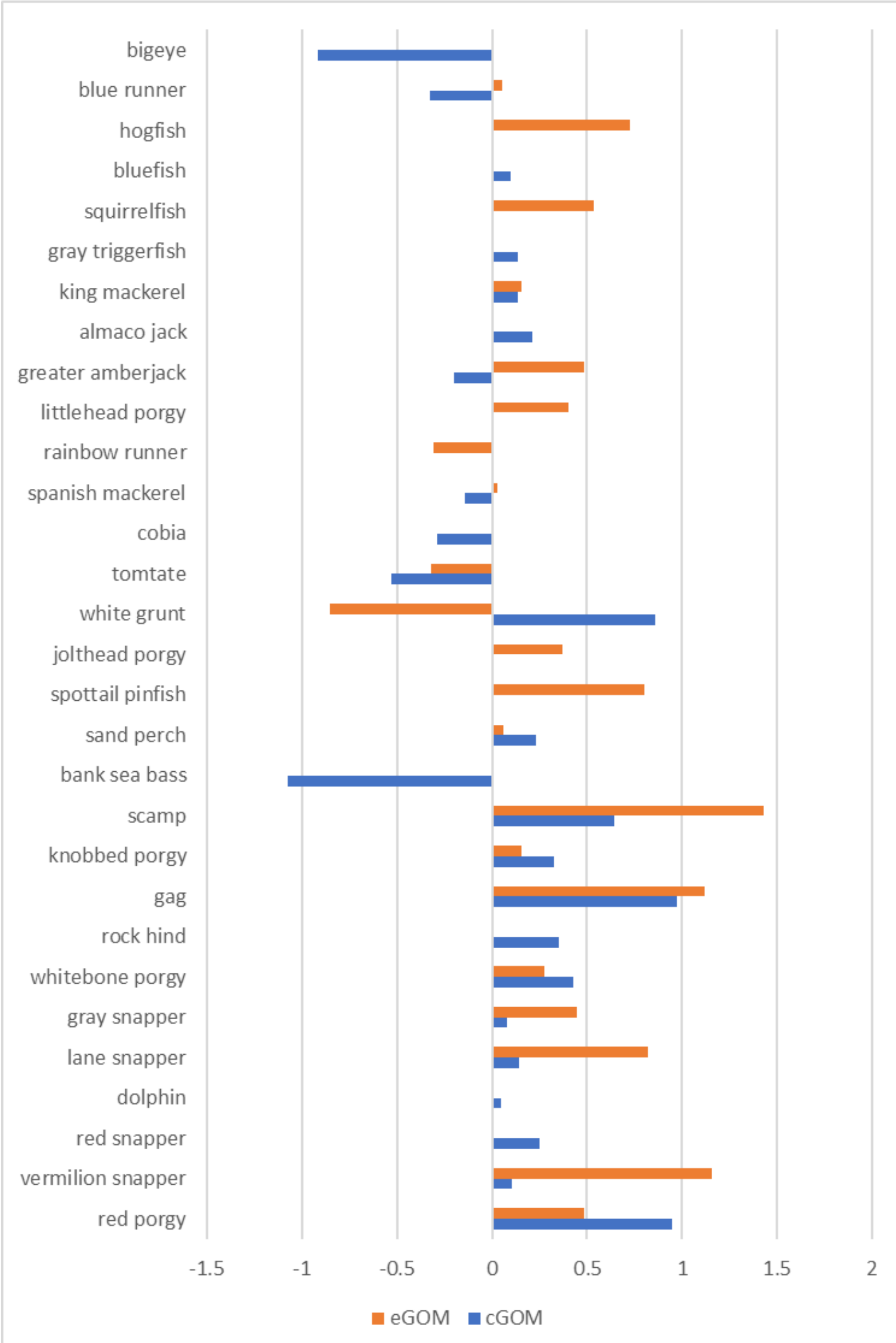


Figure 3. Stephens and MacCall (2004) species-association coefficients of Red Grouper with other species across regions in the US Gulf of Mexico. Positive numbers indicate a positive correlation with red grouper in SRHS logbook catch records.

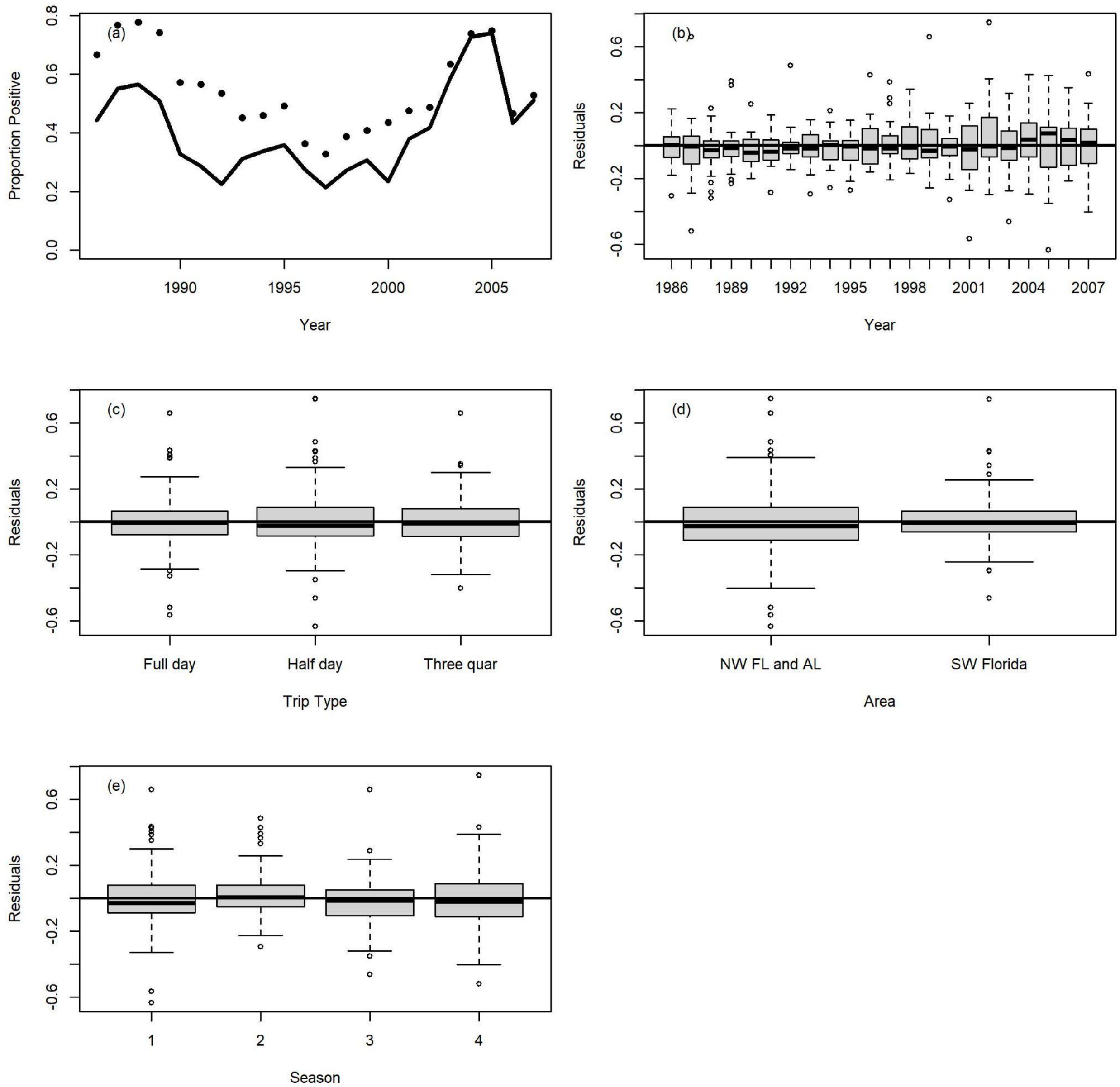


Figure 4. Diagnostic plots for the Binomial component (i.e., proportion positive) of the final delta-lognormal GLM, including the (A) comparison of observed vs. predicted proportion of positive trips (i.e., with red grouper catch) by year and (B) the distribution of residuals by year, (C) trip type, (D) area, and (E) season.

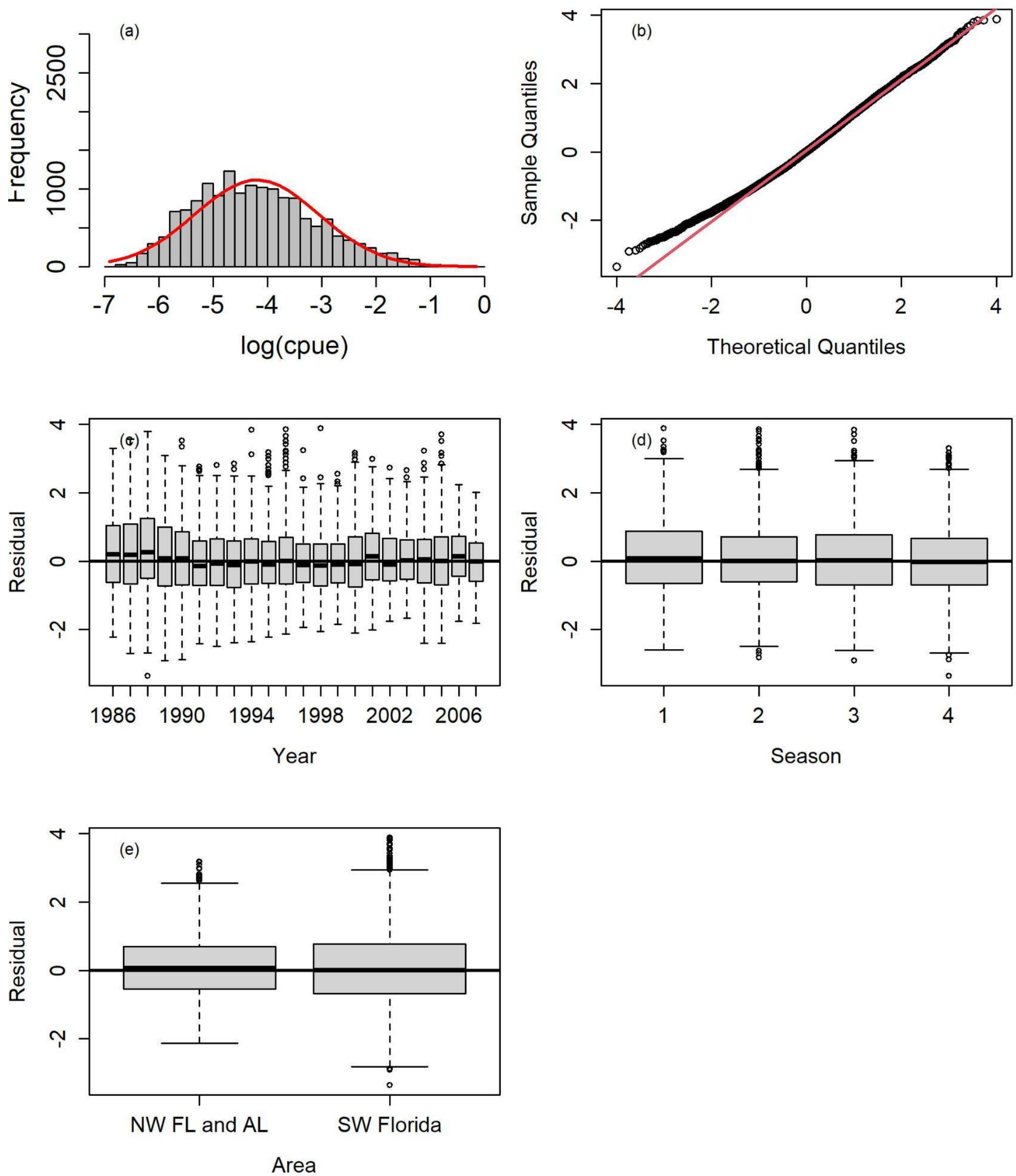
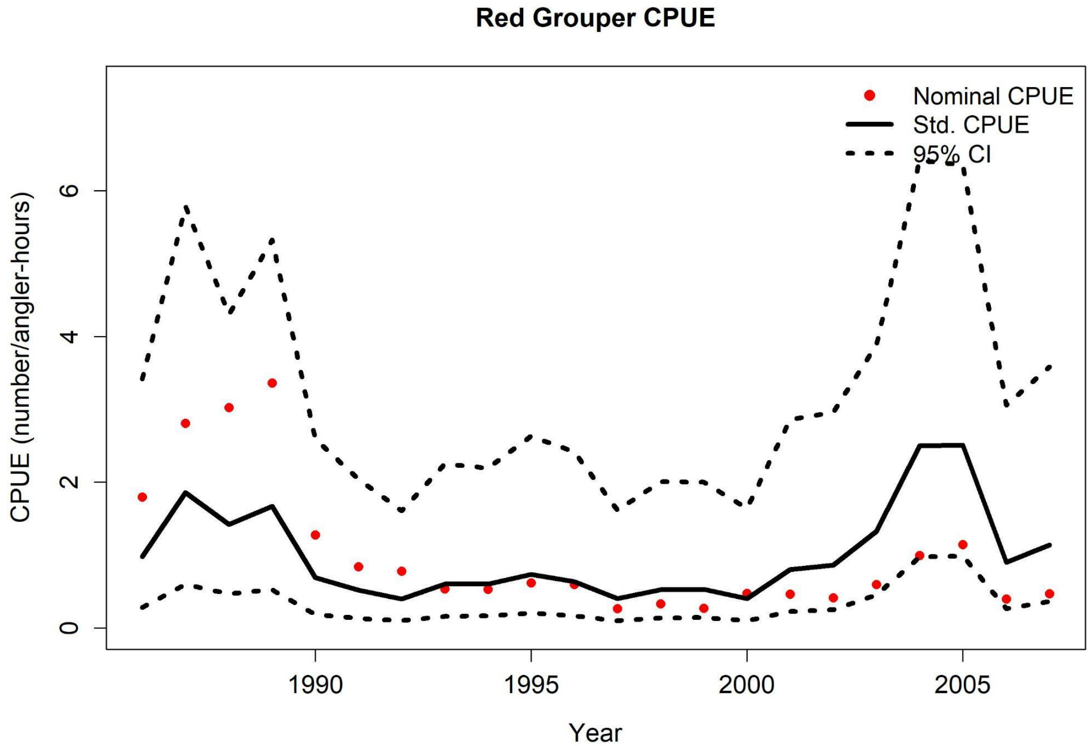


Figure 5. Diagnostic plots for the Lognormal component (i.e., catch rates from positive trips) of the final delta-lognormal GLM, including the (A) frequency distribution of log-transformed catch rates, (B) cumulative normalized residuals, and (C) the distribution of residuals by year, (D) season, and (E) area. The red line added to (A) represents an expected normal distribution.



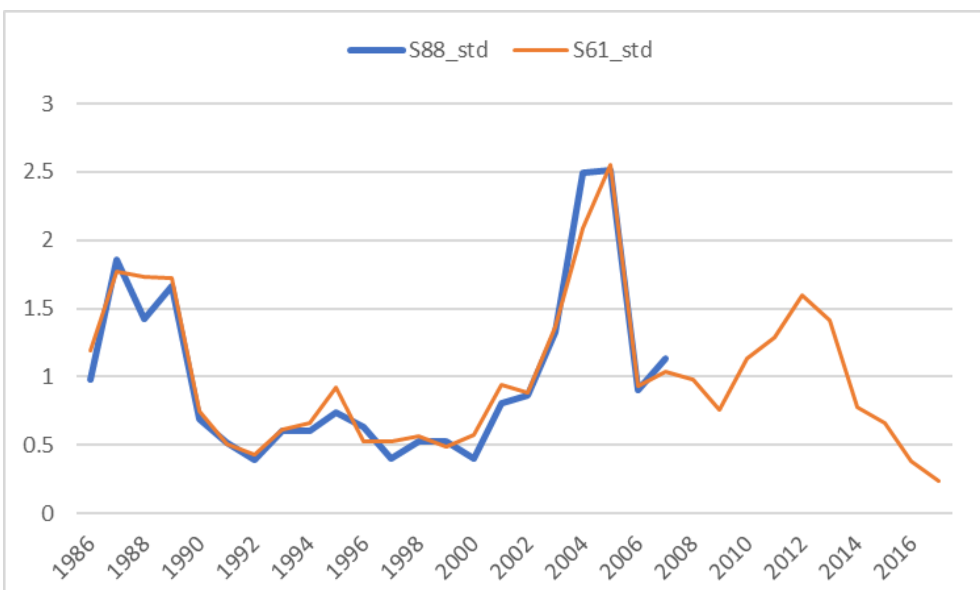


Figure 6. Standardized abundance index, with 95% confidence intervals, for SEDAR 88 Gulf of Mexico red grouper as compared to the associated nominal catch rates, both of which have been scaled to the mean values of their respective time series (top). A comparison of the standardized indices between SEDAR 88 and SEDAR 61 is also provided (bottom).

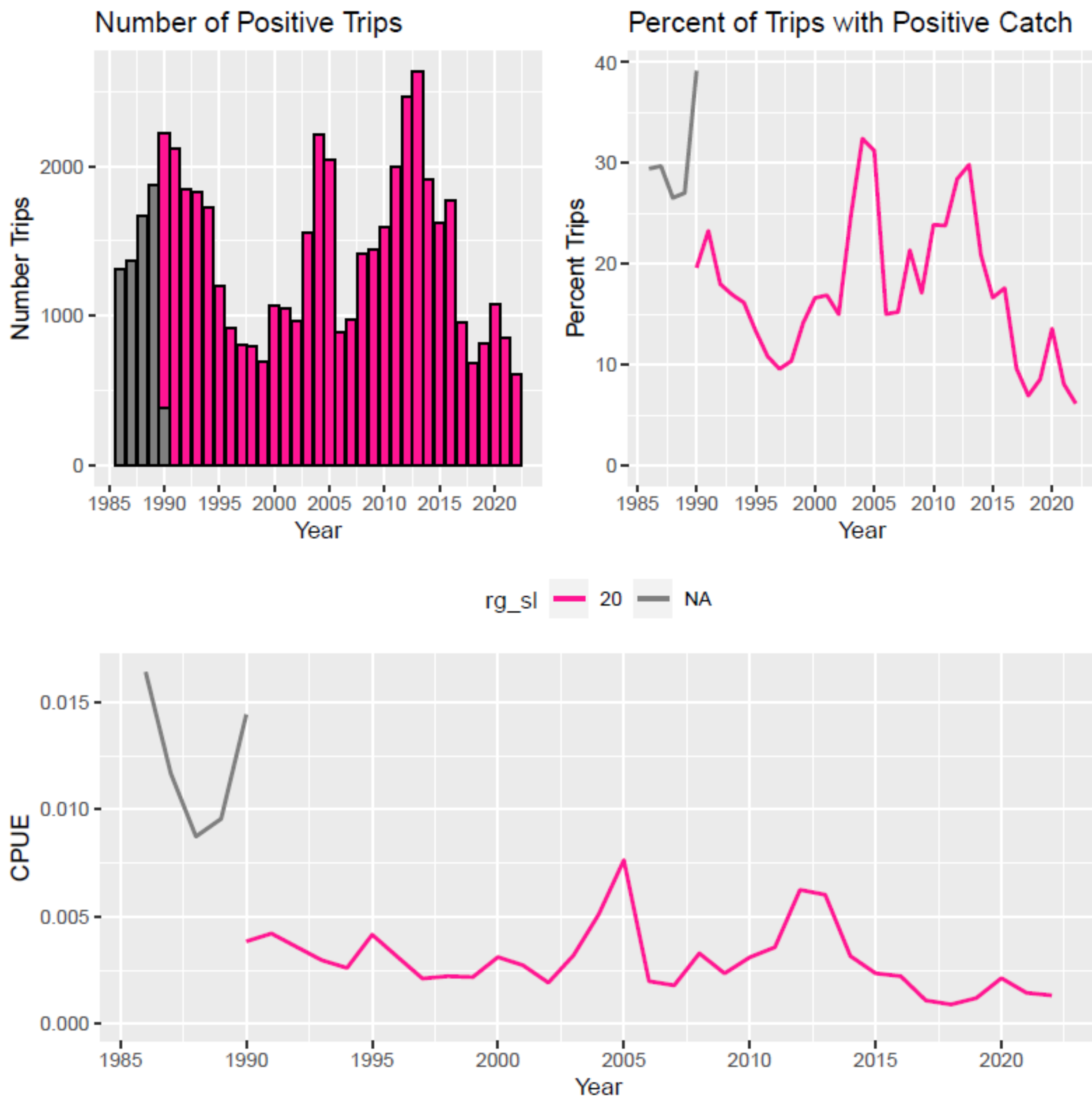


Figure 7. Annual catch rates (i.e., sum(landings) / sum(angler-hours)) and percent of trips with positive catch for red grouper from SRHS logbook records. Trips are grouped based on whether they co-occurred with the 20" federal size limit on Gulf of Mexico red grouper (*rg_sl*), established in 1990.

Appendix A

Table A1. Total number of SRHS trips retained after application of data filters and (Stephens and MacCall) trip selection, as indicative of trips where Gulf of Mexico red grouper were present (i.e., available to be caught).

Year	Area		Trip Type			Season			
	cGOM	eGOM	0.5 day	0.75 day	1.0 day	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov
1986	61	1346	385	143	879	345	373	351	338
1987	119	1114	321	72	840	285	443	316	189
1988	131	1155	363	141	782	261	389	434	202
1989	126	1308	545	294	595	351	385	374	324
1990	95	1991	597	578	911	562	506	487	531
1991	106	1770	482	545	849	558	483	421	414
1992	222	1760	438	583	961	502	492	533	455
1993	296	1588	519	529	836	463	512	511	398
1994	275	1574	442	389	1018	351	556	561	381
1995	325	909	297	426	511	217	356	392	269
1996	587	797	259	376	749	179	343	560	302
1997	687	743	304	325	801	197	382	542	309
1998	614	699	183	476	654	198	338	500	277
1999	310	633	154	339	450	253	432	188	70
2000	270	678	120	287	541	188	302	281	177
2001	384	532	80	350	486	142	309	307	158
2002	336	442	49	435	294	148	234	254	142
2003	524	630	66	847	241	164	271	427	292
2004	432	657	85	737	267	163	390	379	157

2005	596	787	132	737	514	246	438	508	191
2006	402	339	66	485	190	127	209	283	122
2007	345	370	197	351	167	106	204	290	115
ALL	7243	21822	6084	9445	13536	6006	8347	8899	5813

Table A2. Number of Positive SRHS trips, with Gulf of Mexico red grouper catch, retained after application of data filters and (Stephens and MacCall) trip selection.

	Area		Trip Type			Season			
Year	cGOM	eGOM	0.5 day	0.75 day	1.0 day	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov
1986	19	918	168	104	665	214	201	261	261
1987	50	896	208	44	694	215	329	244	158
1988	47	952	292	93	614	204	302	339	154
1989	41	1022	390	199	474	257	292	279	235
1990	28	1164	227	292	673	364	219	313	296
1991	23	1038	134	297	630	287	251	305	218
1992	36	1024	83	316	661	242	236	329	253
1993	124	725	90	245	514	184	179	302	184
1994	97	752	113	218	518	126	220	296	207
1995	102	505	82	247	278	90	178	194	145
1996	181	321	71	85	346	46	128	238	90
1997	183	285	28	70	370	56	116	200	96
1998	138	370	48	88	372	73	100	181	154
1999	85	300	27	97	261	101	158	86	40
2000	68	345	13	49	351	69	126	145	73
2001	193	242	19	121	295	37	144	186	68
2002	170	208	10	167	201	61	111	133	73
2003	333	398	20	514	197	92	152	273	214
2004	337	468	50	529	226	86	273	307	139
2005	472	563	102	532	401	187	340	381	127
2006	245	100	14	177	154	29	94	156	66

2007	173	205	57	202	119	57	102	152	67
ALL	3145	12801	2246	4686	9014	3077	4251	5300	3318

Table A3. Proportion positive (%trips) for those SRHS trips with Gulf of Mexico red grouper catch after application of data filters and (Stephens and MacCall) trip selection.

Year	Area		Trip Type			Season			
	cGOM	eGOM	0.5 day	0.75 day	1.0 day	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov
1986	0.31	0.68	0.44	0.73	0.76	0.62	0.54	0.74	0.77
1987	0.42	0.80	0.65	0.61	0.83	0.75	0.74	0.77	0.84
1988	0.36	0.82	0.80	0.66	0.79	0.78	0.78	0.78	0.76
1989	0.33	0.78	0.72	0.68	0.80	0.73	0.76	0.75	0.73
1990	0.29	0.58	0.38	0.51	0.74	0.65	0.43	0.64	0.56
1991	0.22	0.59	0.28	0.54	0.74	0.51	0.52	0.72	0.53
1992	0.16	0.58	0.19	0.54	0.69	0.48	0.48	0.62	0.56
1993	0.42	0.46	0.17	0.46	0.61	0.40	0.35	0.59	0.46
1994	0.35	0.48	0.26	0.56	0.51	0.36	0.40	0.53	0.54
1995	0.31	0.56	0.28	0.58	0.54	0.41	0.50	0.49	0.54
1996	0.31	0.40	0.27	0.23	0.46	0.26	0.37	0.43	0.30
1997	0.27	0.38	0.09	0.22	0.46	0.28	0.30	0.37	0.31
1998	0.22	0.53	0.26	0.18	0.57	0.37	0.30	0.36	0.56
1999	0.27	0.47	0.18	0.29	0.58	0.40	0.37	0.46	0.57
2000	0.25	0.51	0.11	0.17	0.65	0.37	0.42	0.52	0.41
2001	0.50	0.45	0.24	0.35	0.61	0.26	0.47	0.61	0.43
2002	0.51	0.47	0.20	0.38	0.68	0.41	0.47	0.52	0.51
2003	0.64	0.63	0.30	0.61	0.82	0.56	0.56	0.64	0.73
2004	0.78	0.71	0.59	0.72	0.85	0.53	0.70	0.81	0.89
2005	0.79	0.72	0.77	0.72	0.78	0.76	0.78	0.75	0.66
2006	0.61	0.29	0.21	0.36	0.81	0.23	0.45	0.55	0.54

2007	0.50	0.55	0.29	0.58	0.71	0.54	0.50	0.52	0.58
ALL	0.43	0.59	0.37	0.50	0.67	0.51	0.51	0.60	0.57

Appendix B

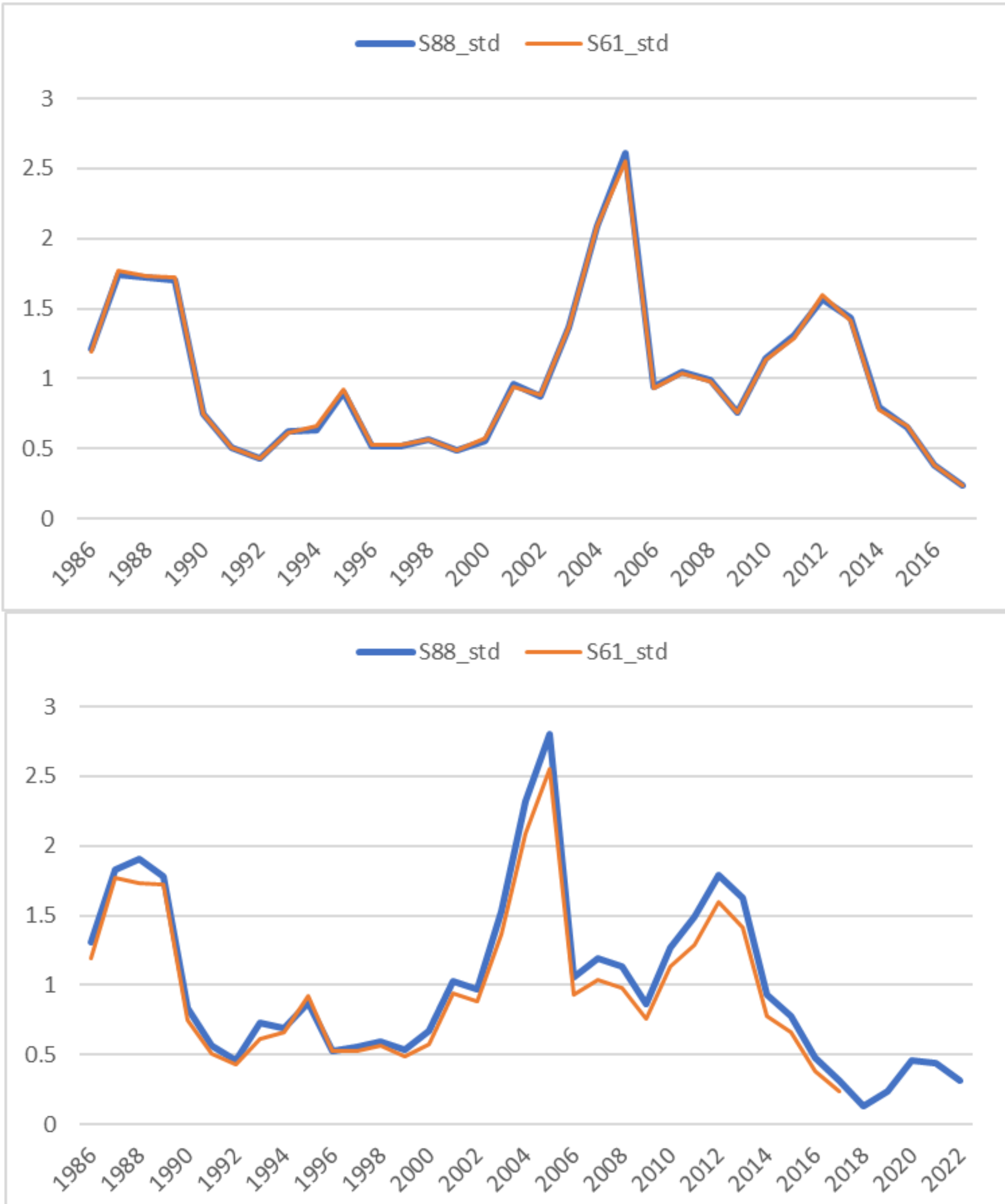


Figure B1. Comparison of standardized indices developed in SEDAR 61 to those generated from a continuity approach in SEDAR 88, which uses the same methodology as that applied in the previous assessment but with newly-pulled data. These continuity comparisons are provided for SRHS abundance indices through the terminal year of the previous assessment (2017; top) and the terminal year of SEDAR 88 (2022; bottom). All indices have been rescaled to the mean values of their respective time series.