Standardized Catch Rate Indices for Vermilion Snapper (*Rhomboplites aurorubens*) during 1986-2017 by the U.S. Gulf of Mexico Charterboat and Private Boat Recreational Fishery

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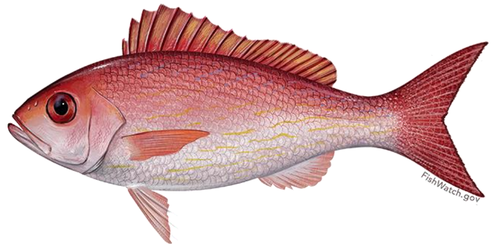

Standardized Catch Rate Indices for Vermilion Snapper (*Rhomboplites aurorubens*) during 1986-2017 by the U.S. Gulf of Mexico Charterboat and Private Boat Recreational Fishery

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Keywords

CPUE, catch, effort, recreational fisheries, Vermilion Snapper

Abstract

A delta-lognormal index was constructed for the SEDAR67 Standard Vermilion Snapper stock assessment. The index uses data from the Marine Recreational Information Program, which underwent a substantial modification and peer-review in 2018 following a three year transition period (2015-2018). An index for the Eastern U.S. Gulf of Mexico is developed following the same methodology and approach used for SEDAR45 and SEDAR09. The resulting index reveals relatively similar index trends when compared to the SEDAR45 index. The SEDAR67 standardized index indicates catch rates were relatively high from 1990-1995, remained relatively low between 1997 and 2008, and have varied around a mean of 1 since 2009.

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. MRIP/MRFSS has monitored shore based, charterboat and private/rental boat angler fishing in the Gulf of Mexico since 1981. MRIP data were used to construct an index of Vermilion Snapper catch rates in the Eastern U.S. Gulf of Mexico following the same procedures used in SEDAR45 and SEDAR09. The index was constructed using a delta-lognormal generalized linear model.

Materials and Methods

MRIP Transition

The Marine Recreational Information Program completed a three year transition in 2018 (NOAA Fisheries 2018). Estimates of fishing effort for the private and shore modes are now obtained from a Fishing Effort Survey conducted via mail, whereas previously these estimates came from the legacy Coastal Household Telephone Survey. Effort estimates for charter and party boats are still obtained from the For-Hire Telephone Survey and are not affected by the new Fishing Effort Survey. Benchmarking of the Fishing Effort Survey alongside the Coastal Household Telephone Survey for three years allowed for apples-to-apples comparisons between data from the two different surveys and the creation of a peer-reviewed calibration model. The calibration model was peer reviewed by reviewers appointed by the Center for Independent Experts (see Rago et al. (2017)). Additional details can be found at: *https://www.fisheries.noaa.gov/event/fishing-effort-survey-calibration-model-peer-review*. The MRIP transition also accounted for the 2013 design change in the Access Point Angler Intercept Survey (Foster et al. 2018). The MRIP transition resulted in the release of new recreational catch estimates for all species and all modes, including charter mode estimates. As a result, the SEFSC conducted a calibration analysis using the newly released data to correct for this change from the Coastal Household Telephone Survey to the For-Hire Telephone Survey (Dettloff and Matter 2019).

MRIP Data

MRIP collects information on participation, effort, and species-specific catch. Data are collected to provide catch and effort estimates in two-month periods ("waves") for each recreational fishing mode (shore fishing, private/rental boat, charterboat, or headboat/charterboat combined prior to 1986) and for each area of fishing (inshore, state Territorial Seas, U.S. Exclusive Economic Zone), in each Gulf of Mexico state (except Texas). Total catch information is collected by MRIP on fish landed whole and observed by interviewers ("Type A"), fish reported as killed by the fishers ("Type B1") and fish reported as released alive by the fishers ("Type B2").

Data from the MRIP dockside interviews were used to characterize abundance trends of Vermilion Snapper in the Eastern U.S. Gulf of Mexico. Information on effort included hours fished and number of anglers as reported to the interviewer. Catch that was not observed by the interviewer (B1 and B2) was adjusted upwards by the ratio of non-interviewed to interviewed anglers in each group of anglers. The catch per unit effort was calculated on an individual group basis (i.e., by leader) and was equal to the number of fish caught (A + B1 + B2) divided by the effort, where effort was the product of the number of anglers and the total hours fished.

MRIP Data Filtering

Data were filtered following the same steps as SEDAR45 and SEDAR09:
1. Data in the Gulf of Mexico were limited to interviews that took place in Mississippi, Alabama, and Florida (including Monroe County)
2. Only interviews associated with private and charterboat fishing modes fishing hook and line gear were retained.
3. Interviews that reported shore-based fishing or fishing in inshore waters were excluded.

4. Interviews with possible error in effort information or in catch amount were excluded.
5. Data prior to 1986 were excluded.
6. Interviews that reached bag limits for Vermilion Snapper were retained.

Species Association

An indirect method was necessary to infer targeting behavior of fishermen because no direct information was available. Following SEDAR45 and SEDAR09, the Stephens and MacCall (2004) approach was used to restrict the dataset to anglers that likely encountered Vermilion Snapper based on the trip's species composition.

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 separate generalized linear model (GLM) analyses of the proportion of leaders that observed Vermilion Snapper and the catch rates under leaders that observed Vermilion Snapper 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 successful 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:

$$ln(CPUE) = ln((A + B1 + B2)/(anglersxhoursfished))$$

A forward stepwise regression approach was utilized within the GENMOD procedure of SAS 9.2 (SAS Institute, 2008). In this procedure, potential 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 < or = 0.05) until no factor reduced the percent deviance by the pre-specified level (i.e., 1%).

The following factors were examined as possible influences on the proportion of positive interviews, and the catch rates on positive interviews:

Name	DF	Details
Year	32	1986-2017
Time of Interview	5	12am-1pm, 2pm, 3pm, 4pm, 5pm-11pm
Season	4	Dec-Feb, Mar-May ,Jun-Aug, Sep-Nov
Red Snapper Season	2	Open, Closed
State	2	FLW, AL/MS
Area	2	<10 miles offshore, > 10 miles offshore
Mode	2	Private, Charterboat

Name	DF	Details
Hours Fished*	4	1-2, 3-4, 5-6, 7+
Anglers*	7	1, 2, 3, 4, 5, 6, 7, 8, 9, 10+

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

The factor Red Snapper season is defined in **Table 1**. All factors were modeled as fixed effects and no interaction terms were examined following SEDAR45. Results of the binomial (proportion positive) and lognormal (mean CPUE on successful trips) 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)

The minimum difference between the predicted and the observed number of interviews that reported Vermilion Snapper occurred at the probability threshold of 0.31 (**Figure 1A**). Interviews with a predicted probability that was greater than the critical threshold probability were identified as interviews that targeted Vermilion Snapper (**Figure 1B**). This method retained 4.2% of interviews, and 64.6% of interviews that reported Vermilion Snapper. Prior to trip selection, there were 214,616 interviews and the proportion positive was 0.04, and after selection there were 8,929 interviews and the proportion positive was 0.65. Given these diagnostics, sufficient interviews were retained to develop a standardized index of abundance.

The Stephens and MacCall (2004) trip subsetting approach identified 52 species which were captured with Vermilion Snapper and reflected either positive or negative associations (**Table 2**; **Figure 2**). For example, Red Porgy, Red Snapper, Gray Triggerfish, Tomtate, and Lane Snapper are positively correlated to Vermilion Snapper while Common Snook, Spotted Seatrout, Bonnethead, Southern Kingfish, and Sheepshead are negatively correlated. Overall, the trends in species associations were relatively similar to the associations identified during SEDAR45, although a few new species were included during SEDAR67 (**Figure 2**).

Annual Abundance Indices

Table 3 summarizes the standardized index, corresponding lower and upper confidence limits, coefficients of variation, and nominal CPUE. Final deviance tables are included in **Table 4**. The final models for the binomial and lognormal components were:

$$ProportionPositive = YEAR + ANGLERS$$

$$ln(CPUE) = YEAR$$

As noted in **Table 4**, variable selection for SEDAR67 identified fewer variables for each model component than during SEDAR45 (**Table 4**, red text). Within the binomial and lognormal GLM components, neither area nor Red Snapper season explained more than 1% deviance explained (**Table 4**).

The standardized index, with 95% confidence intervals, is shown in **Figure 3**. Nominal values generally fell within the 95% confidence intervals, with exceptions noted in 1986 and 1994. Relative abundance peaked in 1986 and generally exceeded 1 (i.e., the mean) until 1995 (**Figure 3**). The lowest relative abundance occurred in 1997, with relatively low values persisting until 2009 (**Figure 3**). Since 2009, relatively abundance has varied around the time series mean of 1 (**Figure 3**).

Diagnostics for each component of the GLM are provided in **Figure 4** and **Figure 5**. The overdispersion parameter for the binomial component was 1.39. The binomial model overestimates the proportion positive at both the beginning (1986-1996) and end (2009+) of the time series (**Figure 4A**). The proportion positive ranged from 0.49 to 0.94, and has generally remained between 0.61 and 0.78. Residual analysis of the binomial model indicated no obvious patterns in the residuals by year (**Figure 4B**), or number of anglers (**Figure 4C**).

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 5A-B**). Residual analysis of the lognormal model also indicated no obvious patterns in the residuals by year (**Figure 5C**).

Figure 6 provides a comparison of the SEDAR67 MRIP index to the MRFSS index derived during SEDAR45. The differences between indices are primarily due to the change in variable selection. Running the index using the SEDAR45 recommended variables results in a much more similar index (results not shown). A fair number of SEDAR67 index values fall outside the confidence intervals of the SEDAR45 index, including 1988, 1992, 1997, 2008, 2009, 2011, 2012 and 2013 (**Figure 7**). However, overall, the relative trend and magnitude of the SEDAR67 index is generally similar to the SEDAR45 index.

Comments on Adequacy for Assessment

The MRIP index presented in this working paper was deemed adequate for use in the SEDAR45 assessment. This decision during SEDAR45 was based on the long time series and large spatial coverage associated with the MRFSS angler intercept data. Additional work is needed to investigate the apparent shift in relative abundance starting in 1997, which is also evident in the headboat index developed for the Eastern U.S. Gulf of Mexico. While this year corresponds to a change in the recreational size limit from 8 inches total length to 10 inches total length, which would have impacted the discarding of fish, discarded fish (B2) were included when developing the MRIP index. In addition, a 20 reef fish aggregate was implemented in 1997, although no issues with exceeding bag limits were identified during this time.

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Tables

Table 1. Red Snapper recreational season lengths by mode, open/close dates, and Federal Register references used for specifying the season in federal waters. F,Sa,Su refers to open only during Friday, Saturday, and Sunday.

Year	Component	Days	Open Date	Close Date	Effective Date	Reference
Pre-1990	Private / For-hire	365	1-Jan	31-Dec		
1990	"	"	"	"		
1991	"	"	"	"		
1992	"	"	"	"		
1993	"	"	"	"		
1994	"	"	"	"		
1995	"	"	"	"		
1996	"	"	"	"		
1997	"	330	"	27-Nov	11/27/1997	62 FR 61700
1998	"	272	"	30-Sep	8/27/1998	63 FR 45760
1999	"	240	"	29-Aug	6/4/1999	64 FR 30445
2000	"	194	21-Apr	1-Nov	1/19/2000 9/18/2000	64 FR 71056 65 FR 50158
2001	"	"	"	"		
2002	"	"	"	"		
2003	"	"	"	"		
2004	"	"	"	"		
2005	"	"	"	"		
2006	"	"	"	"		
2007	"	"	"	"	5/2/2007	72 FR 15617
2008	"	65	1-Jun	5-Aug	8/5/2008	73 FR 15674
2009	"	75	"	15-Aug	8/15/2009	74 FR 21558
2010	"	53	"	24-Jul	6/2/2010	75 FR 23186
2011	"	48	"	19-Jul	9/12/2011	76 FR 50143
2012	"	46	"	17-Jul	7/11/2012	77 FR 39647
2013	"	42	1-Jun	29-Jun 15-Oct	6/29/2013 10/1/2013	78 FR 34586 78 FR 57313
			1-Oct			
2014	"	9	"	10-Jun	5/15/2014	79 FR 27768
2015	Private	10	"	11-Jun	6/1/2015	80 FR 24832
	For-hire	44	"	15-Jul	6/1/2015	80 FR 24832

Year	Component	Days	Open Date	Close Date	Effective Date	Reference
2016	Private	11	"	12-Jun	6/10/2016	81 FR 38110
	For-hire	46	"	17-Jul	6/10/2016	81 FR 25583
2017	Private	42	1-Jun	3-Jun	6/4/2017	82 FR 21140
			16-Jun (F,Sa,Su only)	5-Sep	6/16/2017	82 FR 27777
			3-Jul	4-Jul		
			4-Sep	5-Sep		
	For-hire	49	1-Jun	19-Jul	6/4/2017	82 FR 21140

Table 2. Association coefficients by species. Positive numbers indicate a positive correlation between a given species and Vermilion Snapper.

Coefficient	Common Name	Scientific Name
2.308	Red Porgy	*Pagrus pagrus*
1.913	Red Snapper	*Lutjanus campechanus*
1.580	Gray Triggerfish	*Balistes capriscus*
1.132	Tomtate	*Haemulon aurolineatum*
1.014	Lane Snapper	*Lutjanus synagris*
0.736	Almaco Jack	*Seriola rivoliana*
0.715	Greater Amberjack	*Seriola dumerili*
0.416	Sand Perch	*Diplectrum formosum*
0.384	Red Grouper	*Epinephelus morio*
0.382	Scamp	*Mycteroperca phenax*
0.359	Little Tunny	*Euthynnus alletteratus*
0.276	Bluefish	*Pomatomus saltatrix*
0.268	Blackfin Tuna	*Thunnus atlanticus*
0.238	Round Scad	*Decapterus punctatus*
0.162	Gray Snapper	*Lutjanus griseus*
0.074	Requiem Shark Family	*Carcharhinidae*
0.045	Inshore Lizardfish	*Synodus foetens*
0.039	King Mackerel	*Scomberomorus cavalla*
0.013	Dolphin	*Coryphaena hippurus*
-0.004	Black Grouper	*Mycteroperca bonaci*
-0.045	Pinfish	*Lagodon rhomboides*
-0.059	Pigfish	*Orthopristis chrysoptera*
-0.061	Mutton Snapper	*Lutjanus analis*
-0.096	Gag	*Mycteroperca microlepis*
-0.103	Cobia	*Rachycentron canadum*
-0.153	Blue Runner	*Caranx crysos*
-0.195	Requiem Shark Genus	*Carcharhinus spp.*
-0.241	Great Barracuda	*Sphyraena barracuda*
-0.319	Grunt Family	*Haemulidae*
-0.370	Gulf Flounder	*Paralichthys albigutta*
-0.398	Cero	*Scomberomorus regalis*
-0.415	Atlantic Croaker	*Micropogonias undulatus*
-0.419	White Grunt	*Haemulon plumieri*

Coefficient	Common Name	Scientific Name
-0.517	Sand Seatrout	*Cynoscion arenarius*
-0.545	Hardhead Catfish	*Arius felis*
-0.548	Spanish Mackerel	*Scomberomorus maculatus*
-0.553	Crevalle Jack	*Caranx hippos*
-0.592	Blacktip Shark	*Carcharhinus limbatus*
-0.647	Yellowtail Snapper	*Ocyurus chrysurus*
-0.731	Sailfish	*Istiophorus platypterus*
-0.789	Stingray Genus	*Dasyatis spp.*
-0.807	Gafftopsail Catfish	*Bagre marinus*
-0.827	Red Drum	*Sciaenops ocellatus*
-0.940	Scaled Sardine	*Harengula jaguana*
-1.069	Southern Puffer	*Sphoeroides nephelus*
-1.094	Black Sea Bass	*Centropristis striata*
-1.246	Ladyfish	*Elops saurus*
-2.038	Sheepshead	*Archosargus probatocephalus*
-2.510	Southern Kingfish	*Menticirrhus americanus*
-2.583	Bonnethead	*Sphyrna tiburo*
-3.272	Spotted Seatrout	*Cynoscion nebulosus*
-12.310	Common Snook	*Centropomus undecimalis*

Table 3. Numbers of total and positive interviews, proportion of positive interviews (PPT), relative nominal CPUE, and standardized abundance index statistics for Vermilion Snapper in the Eastern U.S. Gulf of Mexico.

Year	N	Positive N	PPT	Relative Nominal CPUE	Relative Index	Lower 95% CI	Upper 95% CI	CV
1986	176	127	0.722	1.711	2.800	2.296	3.416	0.100
1987	96	60	0.625	1.151	1.179	0.826	1.682	0.179
1988	30	27	0.900	1.716	1.911	1.281	2.851	0.202
1989	79	37	0.468	0.898	0.885	0.543	1.443	0.248
1990	59	45	0.763	1.783	2.229	1.548	3.208	0.184
1991	103	83	0.806	1.525	1.470	1.125	1.919	0.134
1992	182	152	0.835	1.238	1.382	1.129	1.691	0.101
1993	127	97	0.764	1.444	1.536	1.195	1.975	0.126
1994	103	64	0.621	2.078	1.434	1.018	2.020	0.173
1995	60	49	0.817	2.197	1.983	1.406	2.796	0.173
1996	67	41	0.612	1.123	1.007	0.644	1.574	0.226
1997	132	88	0.667	0.305	0.274	0.198	0.379	0.164
1998	190	116	0.611	0.454	0.361	0.269	0.484	0.147
1999	365	232	0.636	0.464	0.387	0.314	0.477	0.104
2000	429	248	0.578	0.360	0.347	0.253	0.475	0.159
2001	395	241	0.610	0.509	0.488	0.360	0.660	0.153
2002	465	242	0.520	0.352	0.363	0.269	0.489	0.151
2003	482	284	0.589	0.440	0.422	0.324	0.550	0.133
2004	726	469	0.646	0.624	0.543	0.439	0.672	0.107
2005	531	368	0.693	0.661	0.581	0.455	0.743	0.123
2006	413	287	0.695	0.583	0.537	0.410	0.703	0.136
2007	369	210	0.569	0.441	0.425	0.311	0.581	0.157
2008	305	187	0.613	0.772	0.662	0.475	0.922	0.167
2009	263	180	0.684	1.167	1.023	0.734	1.428	0.168
2010	281	167	0.594	0.749	0.561	0.393	0.801	0.180
2011	478	363	0.759	1.297	1.311	1.041	1.650	0.116
2012	416	264	0.635	0.773	0.881	0.670	1.159	0.138
2013	204	132	0.647	0.809	1.022	0.746	1.401	0.159
2014	333	251	0.754	1.287	1.186	0.950	1.481	0.111
2015	346	244	0.705	1.024	0.958	0.761	1.207	0.116

Year	N	Positive N	PPT	Relative Nominal CPUE	Relative Index	Lower 95% CI	Upper 95% CI	CV
2016	401	258	0.643	0.837	0.679	0.538	0.855	0.116
2017	307	209	0.681	1.226	1.176	0.929	1.489	0.118

Table 4. Final deviance tables for the regressions for Vermilion Snapper in the Eastern 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. Note that variables in red were included during SEDAR45 but not included for SEDAR67 due to a percent deviance reduction < 1%.

Factor	DF	Deviance	Residual DF	Residual Deviance	AIC	Deviance Reduced	Log likelihood	Likelihood Ratio Test
Binomial								
Null	1	3825	2823	3825	3825	-	-1912	-
Year	32	3524	2792	301	3524	6.86%	-1762	301.6
Anglers	10	3424	2783	99	3424	2.51%	-1712	99.6
Area	2	3408	2782	16	3408	0.44%	-1704	16.4
Lognormal								
Null	1	3047	1661	3047	5724	-	-2862	-
Year	32	2531	1630	515	5415	15.35%	-2707	308.2
Red Snapper Season	2	2513	1629	17	5404	0.65%	-2702	11.8

Figures

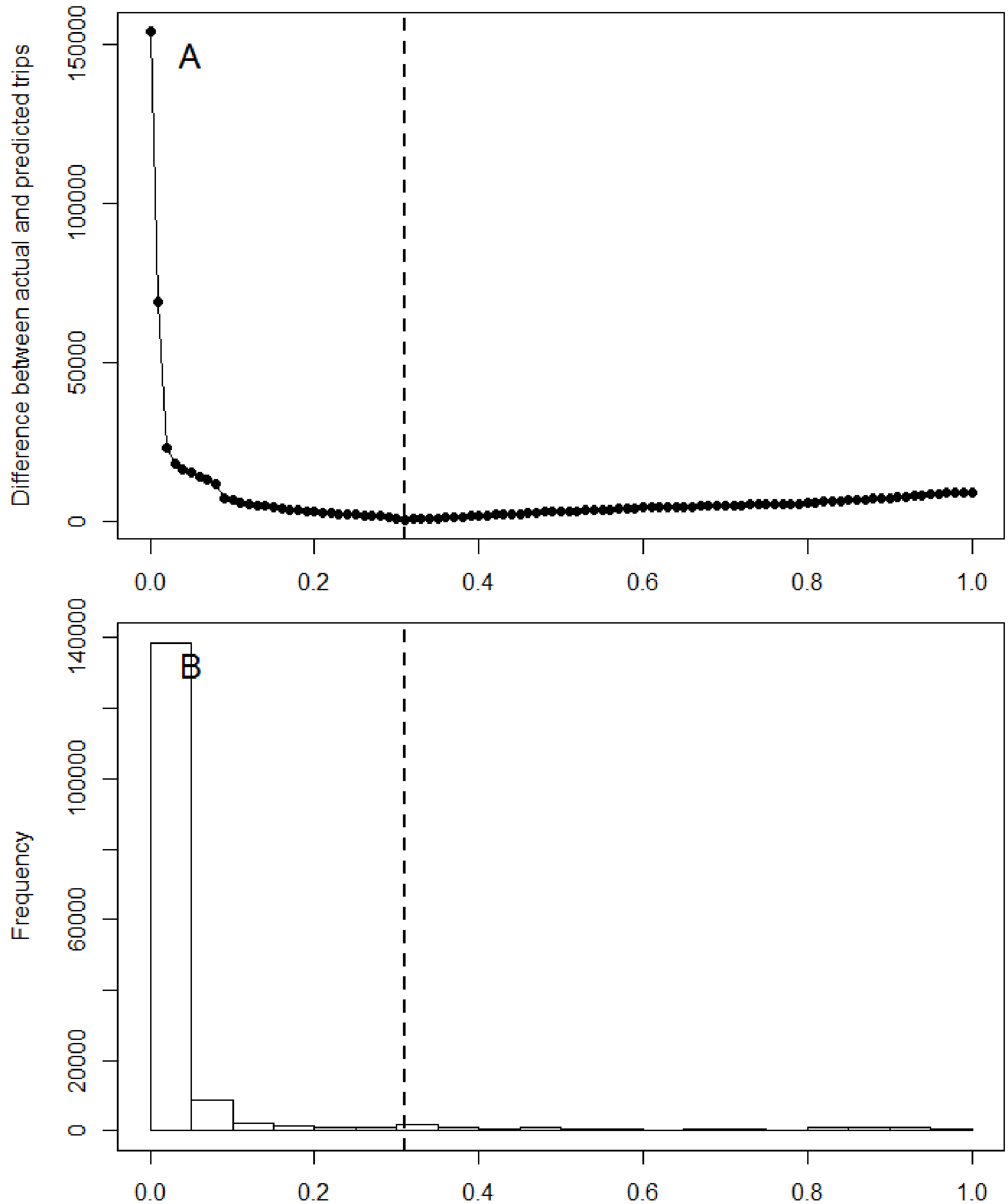

Figure 1. The difference between the number of records in which Vermilion Snapper are observed and the number in which they are predicted to occur for each probability threshold (A). Histogram of probabilities generated by the species-based regression (B). The dashed vertical line indicates the critical value where false prediction is minimized.

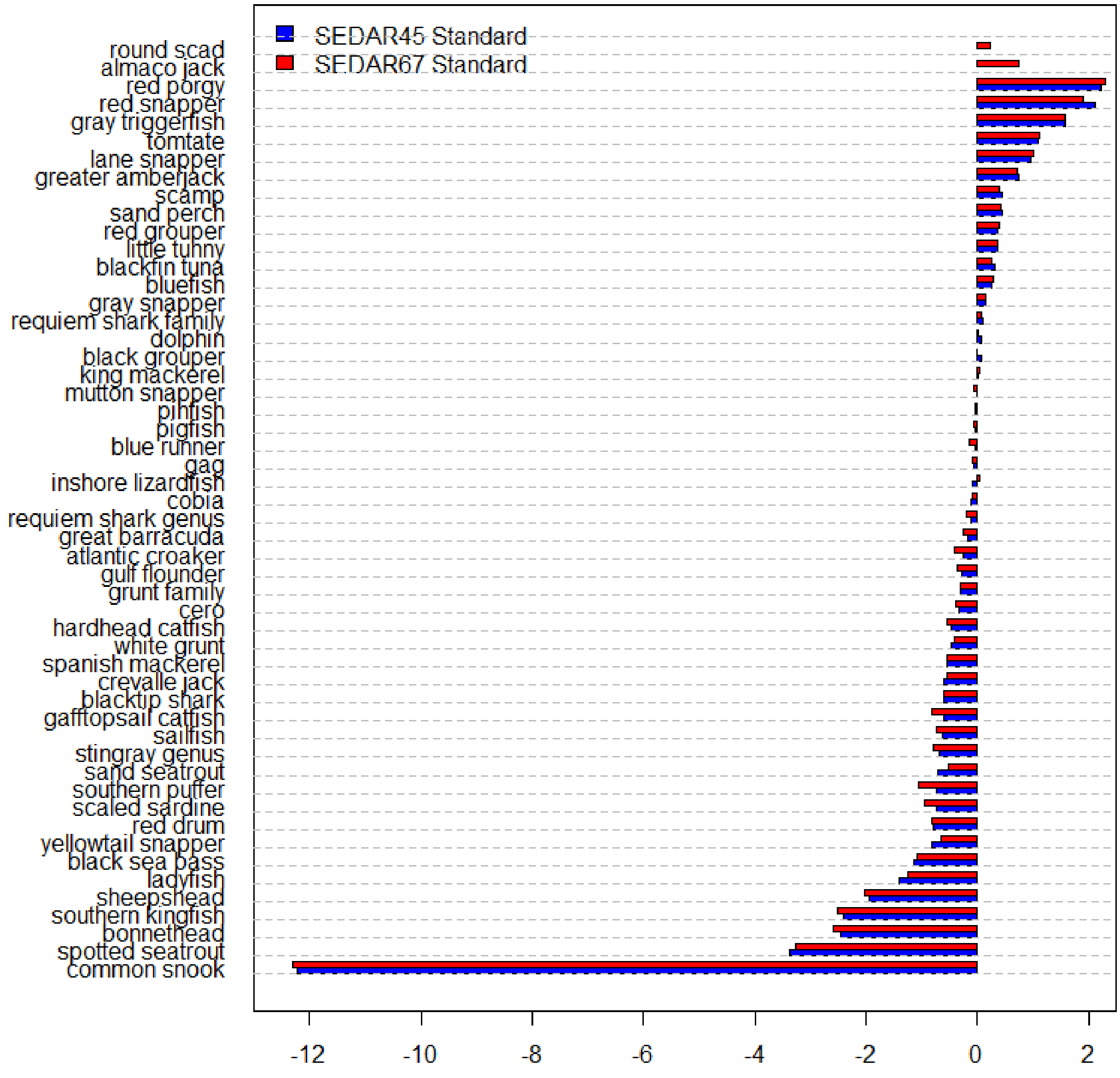

Figure 2. Comparison of coefficients obtained from the Stephens and MacCall (2004) trip selection approach for SEDAR67 and the previous SEDAR45 assessment.

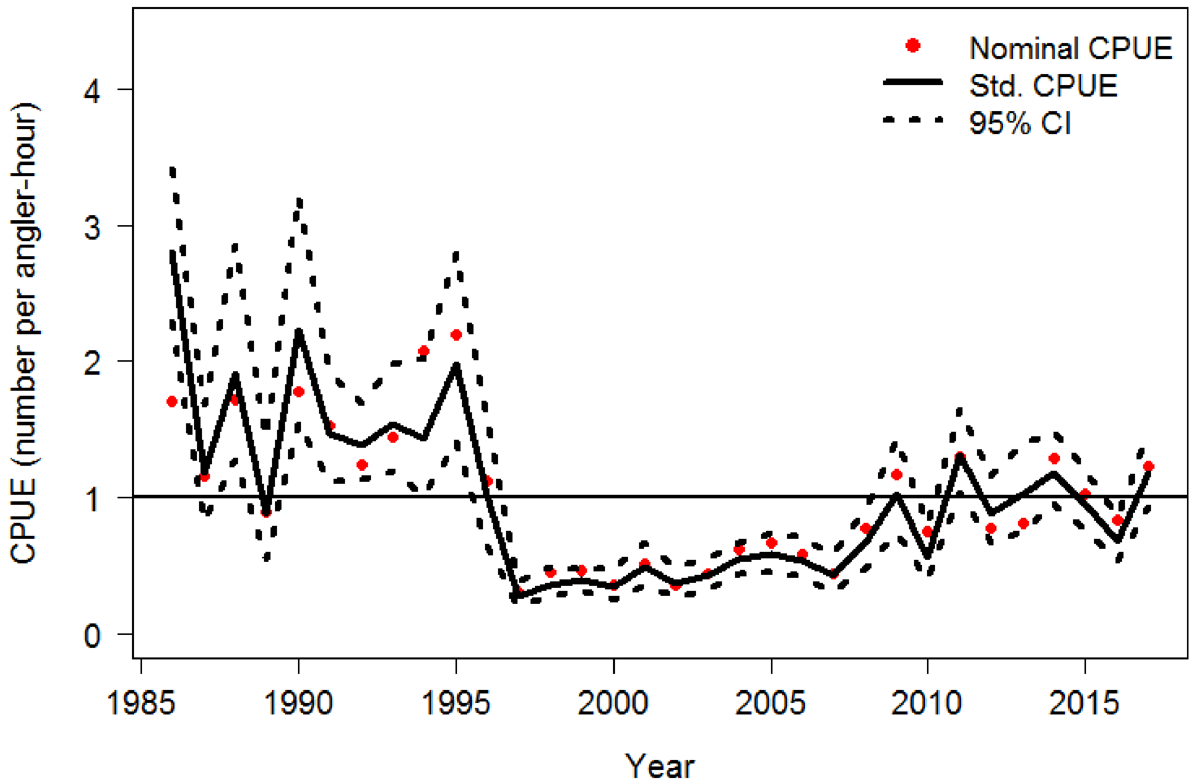

Figure 3. Standardized indices with 95% confidence intervals and nominal CPUE for Vermilion Snapper in the Eastern U.S. Gulf of Mexico.

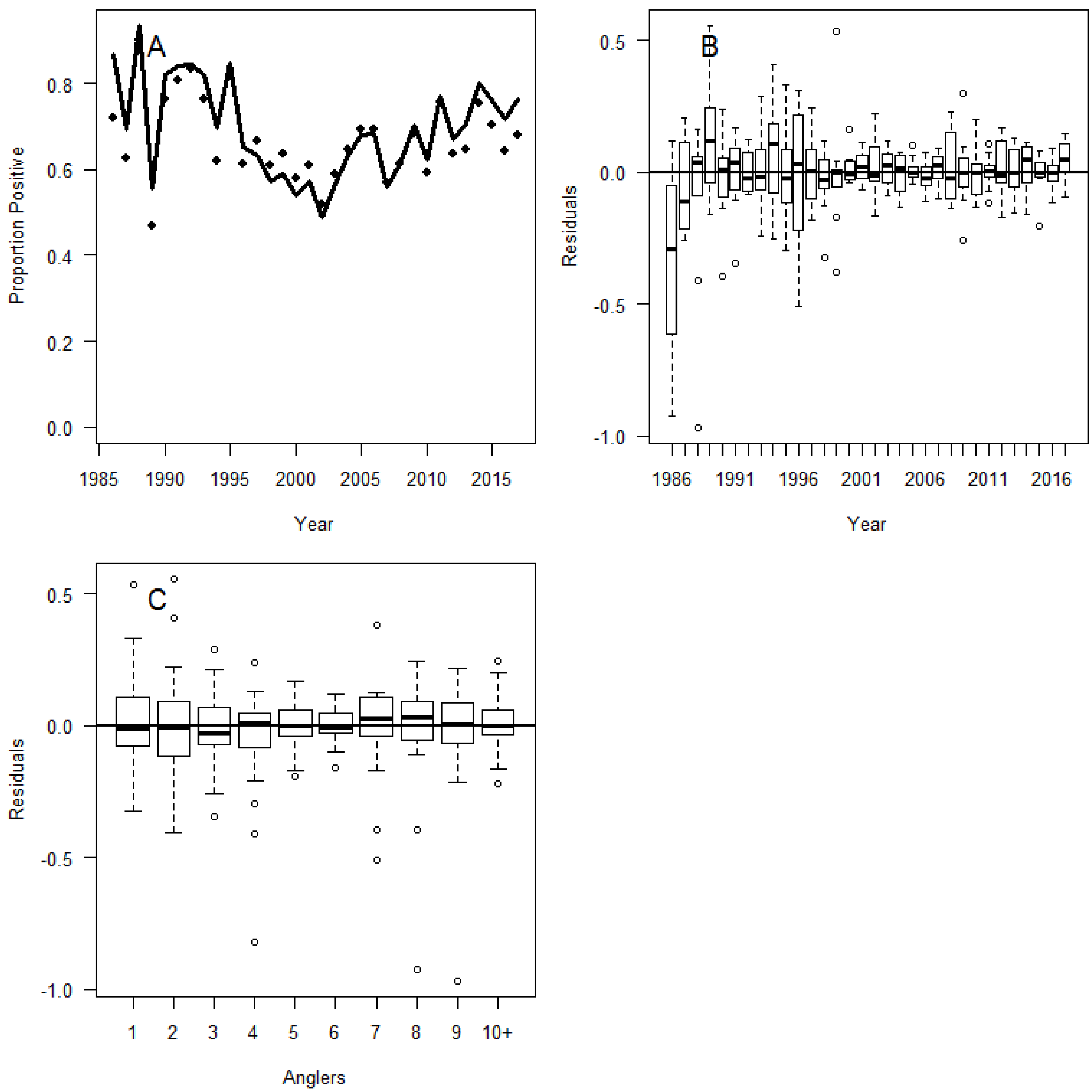

Figure 4. Diagnostic plots for the binomial model for Vermilion Snapper in the Eastern U.S. Gulf of Mexico. Shown here are the predicted (solid line) and observed proportion of positive interviews by year (A), and the residuals from the binomial model by year (B) and number of anglers (C).

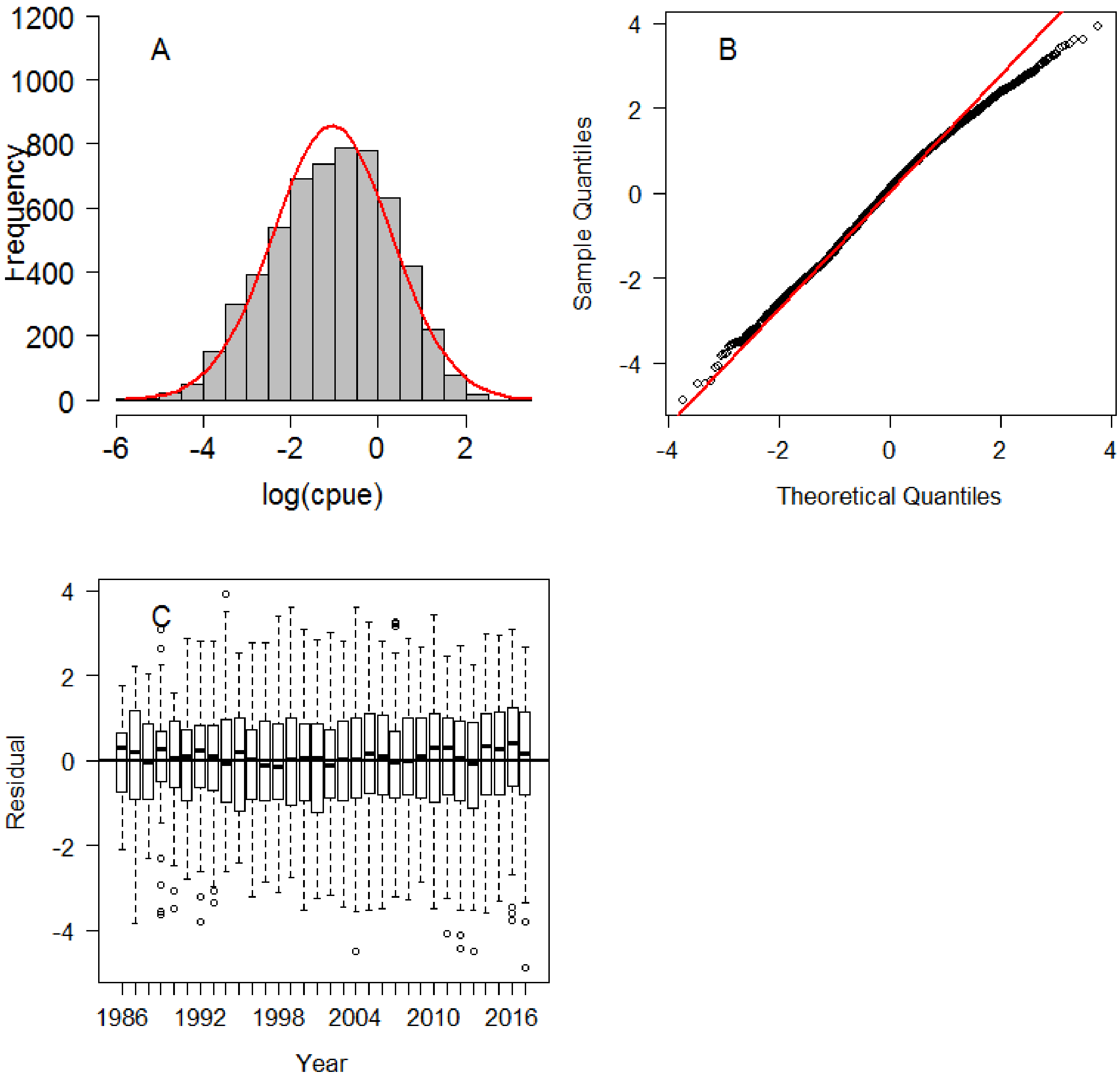

Figure 5. Diagnostic plots for the lognormal model of catch rates on positive trips for Vermilion Snapper in the Eastern U.S. Gulf of Mexico. Shown here are the frequency distribution of catch rates (A), the cumulative normalized residuals (B), and the distribution of residuals by year (C). The red lines represent the expected normal distribution.

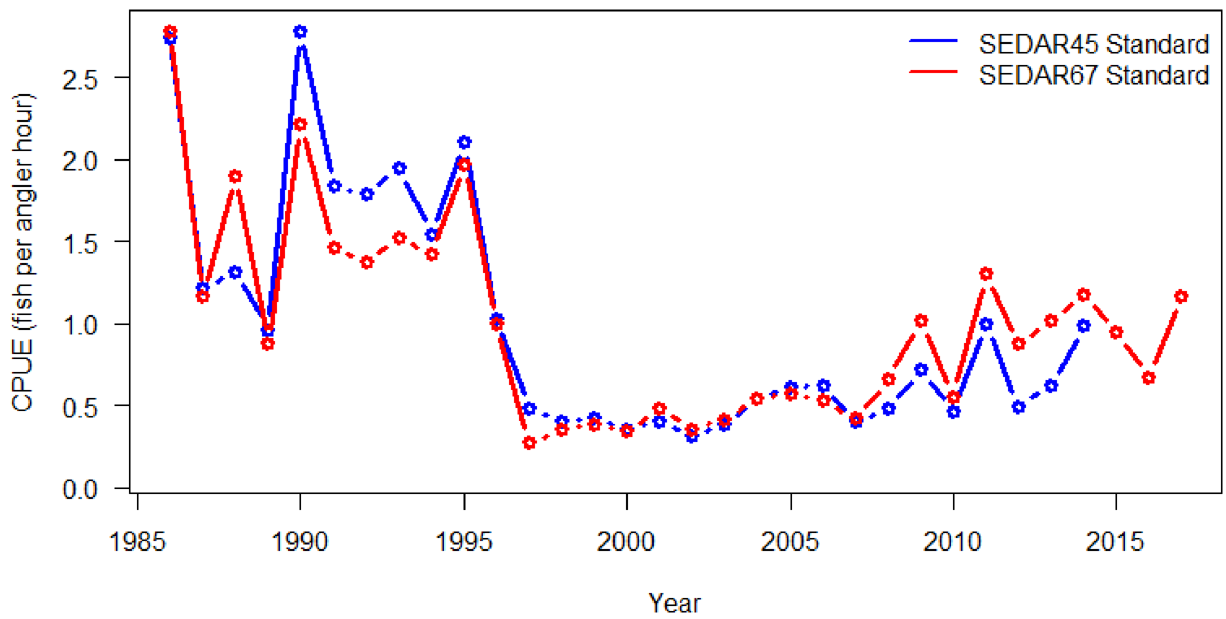

Figure 6. Standardized index for Vermilion Snapper in the Eastern U.S. Gulf of Mexico for SEDAR67 compared to the index provided during SEDAR45. For comparison, both indices have been normalized by their respective means.

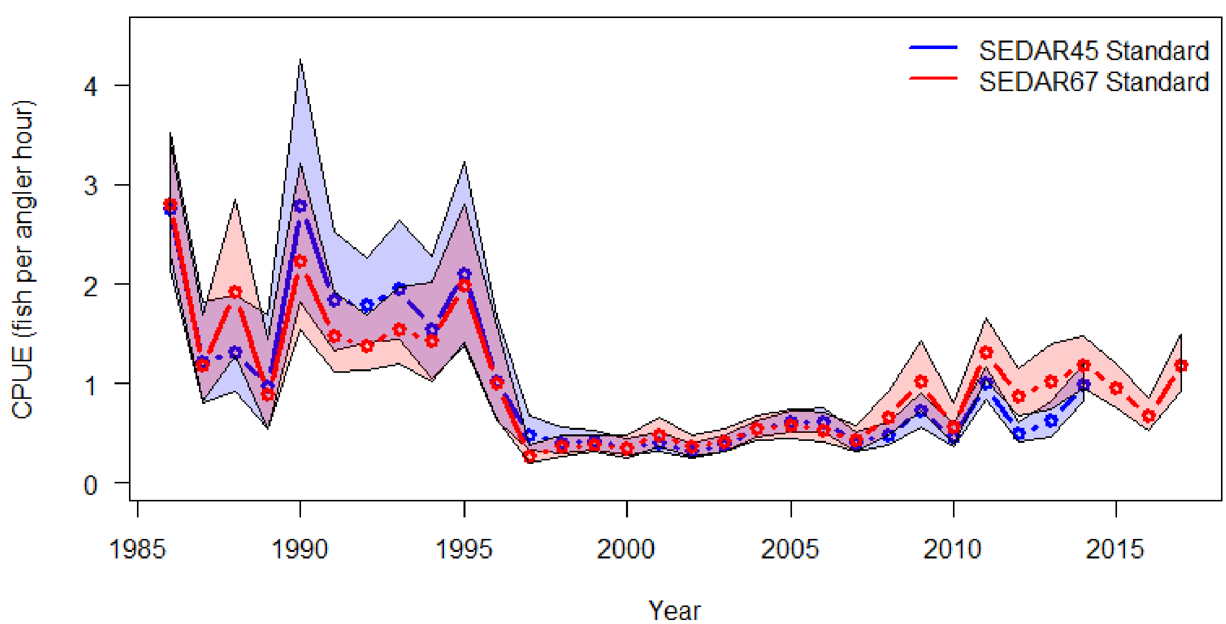

Figure 7. Comparison of index for Vermilion Snapper in the Eastern U.S. Gulf of Mexico for SEDAR67 compared to the index provided during SEDAR45 with confidence intervals.