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

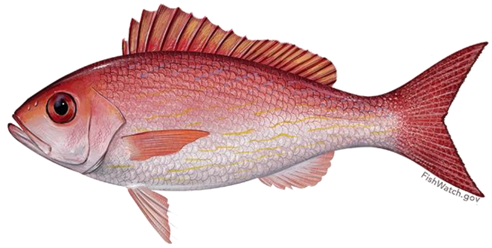
Skyler R. Sagarese

SEDAR67-WP-08

4 November 2019

Please cite this document as:

Sagarese, Skyler R. 2019. Standardized Catch Rate Indices for Vermilion Snapper (*Rhomboplites aurorubens*) during 1986-2017 by the U.S. Gulf of Mexico Headboat Recreational Fishery. SEDAR67-WP-08. SEDAR, North Charleston, SC. 30 pp.



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

Skyler R. Sagarese
skyler.sagarese@noaa.gov
Sustainable Fisheries Division
NOAA Fisheries - Southeast Fisheries Science Center

November, 2019

Keywords

CPUE, catch, effort, recreational fisheries, Vermilion Snapper

Abstract

Two delta-lognormal indices, for the Eastern and Western U.S. Gulf of Mexico, were constructed for the SEDAR67 Standard Vermilion Snapper stock assessment. Each index uses data from the Southeast Region Headboat Survey (HBS). Indices for the Eastern and Western U.S. Gulf of Mexico are developed following the same methodology and approach used for SEDAR45 and SEDAR09. The resulting indices reveal relatively similar trends when compared to the SEDAR45 indices for both regions. For the Eastern U.S. Gulf of Mexico, the SEDAR67 standardized index indicates catch rates were relatively high until 1995 but have remained below the mean since 1996, with the exception of 2017. For the Western U.S. Gulf of Mexico, the SEDAR67 standardized index indicates catch rates have been highly variable throughout the time series, with recent relative abundance near the mean.

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 effort from party (head) boats in the Gulf of Mexico since 1986. SRHS data were used to construct an index of Vermilion Snapper catch rates in both the Eastern and Western 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

Headboat Data

The Southeast Region Headboat Survey 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.

SRHS data were used to characterize abundance trends of Vermilion Snapper in the Eastern and Western U.S. Gulf of Mexico. Catch per unit effort (CPUE) was calculated on an individual trip basis. CPUE for each trip was defined as the number of Vermilion Snapper landed on a trip divided by the 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 necessary: Half day trip = 5 hours fished; Three-quarter day trip = 7.5 hours fished, Full day trip = 10 hours fished; and Multi-day trip = >10 hours fished.

Headboat Data Filtering

Data were filtered following the same steps as SEDAR45 and SEDAR09. Trips were eliminated if they had missing values for any of the key factors, were in anyway incomplete, appeared to be misreported (e.g., reported zero anglers), or represented multiple entries for a single trip. Two indices (Eastern U.S. Gulf of Mexico and Western U.S. Gulf of Mexico) were calculated based on geographic area (east or west of the Mississippi delta) to better represent the variance and abundance trends in each zone, because effort can vary significantly from year-to-year between the two areas.

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 trips that observed Vermilion Snapper and the catch rates under trips 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:

$$ln(CPUE) = ln(Catch)/(anglersxhoursfished))$$

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%). Since the goal of the standardization process was to model time trends in abundance, it was necessary to force the year effect as a factor even if it was not deemed significant. No interaction terms were examined following SEDAR45. Factors modeled as fixed effects included year, season, Red Snapper season (**Table 1**), time of day, trip duration, month and area.

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 be more highly correlated than those far apart in time (Littell et al., 1998).

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

Western U.S. Gulf of Mexico

Species Associations - Stephens and MacCall (2004)

The minimum difference between the predicted and the observed number of trips that reported Vermilion Snapper occurred at the probability threshold of 0.34 (**Figure 1A**). Trips with a predicted probability that was greater than the critical threshold probability were identified as trips that targeted Vermilion Snapper (**Figure 1B**). This method retained 34.2% of trips, and 64.3% of trips that reported Vermilion Snapper. Prior to trip selection, there were 67,723 trips and the proportion positive was 0.34, and after selection there were 23,145 trips and the proportion positive was 0.64. Given these diagnostics, sufficient trips were retained to develop a standardized index of abundance.

The Stephens and MacCall (2004) trip subsetting approach identified 23 species which were captured with Vermilion Snapper and reflected either positive or negative associations (**Table 2**; **Figure 2**). For example, Scamp, Greater Amberjack, Red Snapper, Lane Snapper, and Gray

Triggerfish are positively correlated to Vermilion Snapper while Sand Seatrout, Crevalle Jack, Spanish Mackerel, Atlantic Spadefish, and Gray Snapper are negatively correlated. Trip selection for SEDAR67 identified many more species compared to SEDAR45, with more pelagics and reef fishes associated with Vermilion Snapper (**Figure 2**).

Variable Selection

The following factors 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
Red Snapper Season	2	Open, Closed
Day/Night*	3	Day, Night, Both
Trip Duration*	4	Half Day, Three Quarter Day, Full Day, Multi Day
Month	12	Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec
Vessel	51 (46)	Individual vessels
Area	2	SW TX, MS LA NE TX

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

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:

$$ProportionPositive = YEAR + TRIPDURATION$$

$$ln(CPUE) = YEAR + REDSNAPPERSEASON + VESSEL$$

Variable selection for SEDAR67 identified fewer variables for the binomial model than during SEDAR45 (**Table 4**, red text). Year was not significant in the binomial model (**Table 4**) but was included to force the year effect in the standardization process for SEDAR67.

The standardized index, with 95% confidence intervals, is shown in **Figure 3**. The majority of nominal values fell within the 95% confidence intervals, with the exception of 1986, 1993, 2009 and 2014. Relative abundance peaked in 1990 and has varied around the mean throughout much of the time series, with the exception of the lowest value in 2008 (**Figure 3**). Relative abundance has remained relatively stable since 2010.

Diagnostics for each component of the GLM are provided in **Figure 4** and **Figure 5**. The overdispersion parameter for the binomial component was 3.87. As in the SEDAR45 index, the binomial model consistently underestimates the proportion positive (**Figure 4A**). The proportion positive ranged from 0.28 to 0.69, and has generally remained between 0.49 and 0.56. The proportion positive declined substantially in 2008 to approximately 30%. Residual analysis of the binomial model indicated no obvious patterns in the residuals by year (**Figure 4B**), or trip duration (**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**), red snapper season (**Figure 5D**) or vessel (**Figure 5E**).

Figure 6 provides a comparison of the SEDAR67 headboat index to the headboat index derived during SEDAR45 for the Western U.S. Gulf of Mexico. Although some slight differences are evident, likely due to changes in trip selection, the trend and magnitude of the continuity index are similar to the index developed during SEDAR45. The changes observed in 2013 and 2014 are likely the result of correcting coding errors in the red snapper season (see SEDAR52-WP13). Overall, all index values for SEDAR67 with the exception of 2013 remain within the confidence intervals of the SEDAR45 index (**Figure 7**).

Eastern U.S. Gulf of Mexico

Species Associations - Stephens and MacCall (2004)

The minimum difference between the predicted and the observed number of trips that reported Vermilion Snapper occurred at the probability threshold of 0.37 (**Figure 8A**). Trips with a predicted probability that was greater than the critical threshold probability were identified as trips that targeted Vermilion Snapper (**Figure 8B**). This method retained 38.9% of trips, and 89.8% of trips that reported Vermilion Snapper. Prior to trip selection, there were 180,970 trips and the proportion positive was 0.39, and after selection there were 70,329 trips and the proportion positive was 0.89. Given these diagnostics, sufficient trips were retained to develop a standardized index of abundance.

The Stephens and MacCall (2004) trip subsetting approach identified 34 species which were captured with Vermilion Snapper and reflected either positive or negative associations (**Table 5**; **Figure 9**). For example, Red Porgy, Red Snapper, Littlehead Porgy, Gray Triggerfish, and Almaco Jack are positively correlated to Vermilion Snapper while White Grunt, Black Sea Bass, Hogfish, Black Grouper, and Pigfish are negatively correlated. Trip selection for SEDAR67 identified many more species compared to SEDAR45, with more pelagics and reef fishes associated with Vermilion Snapper (**Figure 9**).

Variable Selection

The following factors 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
Red Snapper Season	2	Open, Closed
Day/Night*	3	Day, Night, Both

Name	DF	Details
Trip Duration*	4	Half Day, Three Quarter Day, Full Day, Multi Day
Month	12	Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec
Vessel	126 (102)	Individual vessels
Area	2	FL MG NW FL AL, SW FL

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

Annual Abundance Indices

Table 6 summarizes the standardized index, corresponding lower and upper confidence limits, coefficients of variation, and nominal CPUE. Final deviance tables are included in **Table 7**. The final models for the binomial and lognormal components were:

$$ProportionPositive = YEAR + AREA + TRIPDURATION$$

$$ln(CPUE) = YEAR + MONTH + VESSEL$$

Variable selection for SEDAR67 identified fewer variables for each model component than during SEDAR45 (**Table 7**, red text). Note that red snapper season was not significant in the SEDAR67 lognormal model, whereas it was significant in the SEDAR45 lognormal model (**Table 7**).

The standardized index, with 95% confidence intervals, is shown in **Figure 10**. The majority of nominal values fell within the 95% confidence intervals, with the exception of 1994, 1998, 2000, 2001, 2004 and 2017. Relative abundance was relatively high during the beginning of the time series, peaked in 1992 and declined until the lowest value in 1998 (**Figure 10**). Relative abundance has gradually increased since 1998, with a few dips noted in 2007 and 2012.

Diagnostics for each component of the GLM are provided in **Figure 11** and **Figure 12** and are similar to the patterns displayed in the SEDAR45 index. The overdispersion parameter for the binomial component was 7.90. As in the SEDAR45 index, the binomial model consistently underestimates the proportion positive (**Figure 11A**). The proportion positive ranged from 0.43 to 0.93, 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 11B**), area (**Figure 11C**) or trip duration (**Figure 4D**).

The lognormal model results suggest a less than optimal fit to the data and indicated that the assumption of a lognormal distribution for positive catch was appropriate for the data (**Figure 12A-B**). Residual analysis of the lognormal model also indicated no obvious patterns in the residuals by year (**Figure 12C**), month (**Figure 12D**) or vessel (**Figure 12E**).

Figure 13 provides a comparison of the SEDAR67 headboat index to the headboat index derived during SEDAR45 for the Eastern U.S. Gulf of Mexico. The continuity index is very similar to the index developed during SEDAR45, although some differences are evident starting in 2008 (**Figure 13**). However, all index values for SEDAR67 remain within the confidence intervals of the SEDAR45 index (**Figure 14**).

Comments on Adequacy for Assessment

The headboat indices presented in this working paper reflect the continuity indices of the headboat indices that were deemed adequate for use in the SEDAR45 assessment. Additional work is needed to investigate the apparent shift in relative abundance starting in 1997, which is also evident in the MRIP index developed for the Eastern U.S. Gulf of Mexico. This year corresponds to a change in the recreational size limit from 8 inches total length to 10 inches total length. This regulation change would have impacted discarded fish which are not reported in the SRHS, although they are reported in the MRIP dataset. In addition, a 20 reef fish aggregate was implemented in 1997, although no issues with exceeding bag limits were identified during this time.

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.

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

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

Tables

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

Year	Mode	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	Mode	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 for Western U.S. Gulf of Mexico. Positive numbers indicate a positive correlation between a given species and Vermilion Snapper.

Coefficient	Common Name	Scientific Name
1.828	Scamp	*Mycteroperca phenax*
1.807	Greater Amberjack	*Seriola dumerili*
1.699	Red Snapper	*Lutjanus campechanus*
1.596	Lane Snapper	*Lutjanus synagris*
1.270	Gray Triggerfish	*Balistes capriscus*
1.145	Almaco Jack	*Seriola rivoliana*
0.949	Warsaw Grouper	*Epinephelus nigritus*
0.846	Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*
0.750	Blackfin Tuna	*Thunnus atlanticus*
0.739	King Mackerel	*Scomberomorus cavalla*
0.671	Rock Hind	*Epinephelus adscensionis*
0.417	Dolphin	*Coryphaena hippurus*
0.250	Blue Runner	*Caranx crysos*
0.199	Cobia	*Rachycentron canadum*
0.025	Blacktip Shark	*Carcharhinus limbatus*
-0.108	Gag	*Mycteroperca microlepis*
-0.255	Bluefish	*Pomatomus saltatrix*
-0.310	Little Tunny	*Euthynnus alletteratus*
-0.337	Gray Snapper	*Lutjanus griseus*
-0.616	Atlantic Spadefish	*Chaetodipterus faber*
-0.829	Spanish Mackerel	*Scomberomorus maculatus*
-0.845	Crevalle Jack	*Caranx hippos*
-1.186	Sand Seatrout	*Cynoscion arenarius*

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

Year	N	Positive N	PPT	Relative Nominal CPUE	Relative Index	Lower 95% CI	Upper 95% CI	CV
1986	666	425	0.638	0.996	1.752	1.121	2.738	0.226
1987	833	576	0.691	0.872	1.223	0.799	1.873	0.215
1988	736	450	0.611	0.732	0.928	0.586	1.470	0.233
1989	703	439	0.624	1.135	1.291	0.832	2.001	0.222
1990	706	500	0.708	1.622	1.767	1.175	2.657	0.206
1991	761	471	0.619	1.011	0.983	0.648	1.493	0.211
1992	1084	683	0.630	0.832	0.945	0.638	1.398	0.198
1993	1184	798	0.674	0.725	1.150	0.797	1.659	0.185
1994	1292	891	0.690	0.830	1.137	0.795	1.627	0.180
1995	1331	926	0.696	0.874	1.214	0.851	1.732	0.179
1996	1064	736	0.692	0.749	0.886	0.612	1.281	0.186
1997	898	579	0.645	0.794	0.837	0.564	1.242	0.199
1998	915	582	0.636	0.699	0.796	0.545	1.163	0.191
1999	513	343	0.669	0.524	0.687	0.444	1.063	0.221
2000	678	457	0.674	0.709	0.519	0.340	0.793	0.214
2001	815	503	0.617	0.757	0.836	0.556	1.256	0.206
2002	874	556	0.636	0.742	0.974	0.664	1.429	0.193
2003	974	551	0.566	0.696	0.636	0.435	0.929	0.191
2004	986	603	0.612	1.007	1.091	0.751	1.585	0.188
2005	1034	609	0.589	0.957	1.218	0.843	1.761	0.186
2006	1067	550	0.515	0.581	0.652	0.437	0.972	0.202
2007	838	496	0.592	1.223	1.438	0.976	2.117	0.195
2008	329	124	0.377	0.282	0.261	0.142	0.481	0.313
2009	524	242	0.462	0.574	0.344	0.215	0.551	0.238
2010	381	264	0.693	1.215	1.140	0.728	1.784	0.227
2011	320	227	0.709	1.706	1.165	0.744	1.824	0.227
2012	353	211	0.598	1.290	0.913	0.571	1.460	0.238
2013	296	234	0.791	1.642	1.103	0.686	1.771	0.240
2014	240	175	0.729	1.651	0.896	0.526	1.527	0.271
2015	277	214	0.773	1.627	1.053	0.660	1.680	0.237

Year	N	Positive N	PPT	Relative Nominal CPUE	Relative Index	Lower 95% CI	Upper 95% CI	CV
2016	235	194	0.826	1.731	1.151	0.707	1.874	0.247
2017	238	160	0.672	1.216	1.015	0.591	1.742	0.275

Table 4. Final deviance tables for the regressions for Vermilion Snapper in the Western 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 variable in red was included in SEDAR67 to force the year effect in the standardization process.

Factor	DF	Deviance	Residual DF	Residual Deviance	AIC	Deviance Reduced	Log likelihood	Likelihood Ratio Test
Binomial								
Null	1	30295	23144	30295	30295	-	-15147	-
Trip Duration	4	28498	23141	1796	28499	5.92%	-14249	1796.6
Year	32	28192	23110	306	28192	0.94%	-14096	306.8
Lognormal								
Null	1	28871	14769	28871	51815	-	-25907	-
Vessel	46	24851	14724	4020	49600	13.66%	-24800	2215.2
Red Snapper Season	2	23180	14723	1670	48572	6.72%	-24286	1028
Year	32	22471	14692	708	48113	2.85%	-24056	458.4

Table 5. Association coefficients by species for Eastern U.S. Gulf of Mexico. Positive numbers indicate a positive correlation between a given species and Vermilion Snapper.

Coefficient	Common Name	Scientific Name
3.006	Red Porgy	*Pagrus pagrus*
1.856	Red Snapper	*Lutjanus campechanus*
1.535	Littlehead Porgy	*Calamus proridens*
1.484	Gray Triggerfish	*Balistes capriscus*
1.321	Almaco Jack	*Seriola rivoliana*
1.157	Whitebone Porgy	*Calamus leucosteus*
1.081	Banded Rudderfish	*Seriola zonata*
0.820	Lane Snapper	*Lutjanus synagris*
0.743	King Mackerel	*Scomberomorus cavalla*
0.688	Tomtate	*Haemulon aurolineatum*
0.650	Dolphin	*Coryphaena hippurus*
0.641	Scamp	*Mycteroperca phenax*
0.562	Knobbed Porgy	*Calamus nodosus*
0.537	Greater Amberjack	*Seriola dumerili*
0.435	Bank Sea Bass	*Centropristis ocyurus*
0.362	Little Tunny	*Euthynnus alletteratus*
0.359	Yellowtail Snapper	*Ocyurus chrysurus*
0.159	Red Grouper	*Epinephelus morio*
0.112	Blue Runner	*Caranx crysos*
0.085	Cobia	*Rachycentron canadum*
0.035	Pinfish	*Lagodon rhomboides*
0.021	Gray Snapper	*Lutjanus griseus*
-0.060	Saucereye Porgy	*Calamus calamus*
-0.194	Jolthead Porgy	*Calamus bajonado*
-0.255	Gag	*Mycteroperca microlepis*
-0.327	Gulf Flounder	*Paralichthys albigutta*
-0.390	Sand Perch	*Diplectrum formosum*
-0.448	Grass Porgy	*Calamus arctifrons*
-0.612	Spanish Mackerel	*Scomberomorus maculatus*
-0.862	Pigfish	*Orthopristis chrysoptera*
-0.972	Black Grouper	*Mycteroperca bonaci*
-0.988	Hogfish	*Lachnolaimus maximus*
-1.257	Black Sea Bass	*Centropristis striata*

Coefficient	Common Name	Scientific Name
-1.879	White Grunt	*Haemulon plumieri*

Table 6. Numbers of total and positive trips, proportion of positive trips (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	641	452	0.705	0.851	0.900	0.546	1.485	0.254
1987	829	650	0.784	1.244	1.009	0.624	1.629	0.243
1988	1782	1664	0.934	2.167	2.163	1.546	3.027	0.169
1989	1779	1580	0.888	1.413	1.343	0.958	1.882	0.170
1990	2322	1976	0.851	1.475	1.689	1.234	2.312	0.158
1991	2229	1953	0.876	1.485	1.803	1.321	2.461	0.157
1992	2417	2233	0.924	1.879	2.499	1.855	3.366	0.150
1993	2783	2502	0.899	1.359	1.599	1.175	2.175	0.155
1994	2554	2334	0.914	1.263	1.766	1.303	2.393	0.153
1995	2586	2382	0.921	1.242	1.489	1.076	2.061	0.164
1996	2530	2257	0.892	0.854	0.822	0.581	1.163	0.175
1997	2599	2295	0.883	0.793	0.736	0.522	1.036	0.173
1998	2466	1926	0.781	0.301	0.190	0.130	0.279	0.193
1999	1525	1313	0.861	0.579	0.421	0.280	0.632	0.205
2000	2186	1788	0.818	0.548	0.354	0.240	0.521	0.196
2001	2227	1935	0.869	0.644	0.442	0.304	0.642	0.188
2002	2145	1892	0.882	0.611	0.482	0.333	0.698	0.186
2003	2085	1891	0.907	0.821	0.587	0.408	0.846	0.184
2004	2015	1842	0.914	0.922	0.629	0.440	0.897	0.179
2005	1692	1579	0.933	0.895	0.812	0.567	1.162	0.181
2006	1597	1433	0.897	0.699	0.561	0.381	0.824	0.195
2007	1629	1377	0.845	0.515	0.372	0.248	0.557	0.204
2008	2341	2013	0.860	0.748	0.667	0.470	0.948	0.177
2009	2618	2207	0.843	0.990	0.790	0.560	1.114	0.173
2010	1572	1418	0.902	1.031	0.860	0.591	1.252	0.189
2011	2587	2313	0.894	1.184	1.058	0.755	1.484	0.170
2012	2643	2352	0.890	0.788	0.656	0.467	0.921	0.171
2013	2700	2473	0.916	0.876	0.892	0.653	1.219	0.157
2014	2742	2569	0.937	0.859	0.948	0.707	1.270	0.147
2015	2714	2532	0.933	0.870	0.898	0.671	1.202	0.146

Year	N	Positive N	PPT	Relative Nominal CPUE	Relative Index	Lower 95% CI	Upper 95% CI	CV
2016	2936	2789	0.950	0.911	0.957	0.726	1.262	0.139
2017	2858	2778	0.972	1.183	1.603	1.237	2.079	0.130

Table 7. 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 variable in red was 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	48302	70328	48302	48303	-	-24151	-
Area	2	43047	70327	5255	43047	10.88%	-21523	5255.8
Year	32	41274	70296	1772	41274	4.08%	-20637	1772.8
Trip Duration	4	40763	70293	511	40763	1.23%	-20381	511.2
Lognormal								
Null	1	98083	62696	98083	205983	-	-102991	-
Vessel	102	77153	62595	20929	190935	21.21%	-95467	15048.2
Year	32	66452	62564	10700	181574	13.83%	-90787	9361.2
Month	12	65230	62553	1222	180409	1.82%	-90204	1164.2
Red Snapper Season	2	64610	62552	620	179810	0.95%	-89905	599

Figures

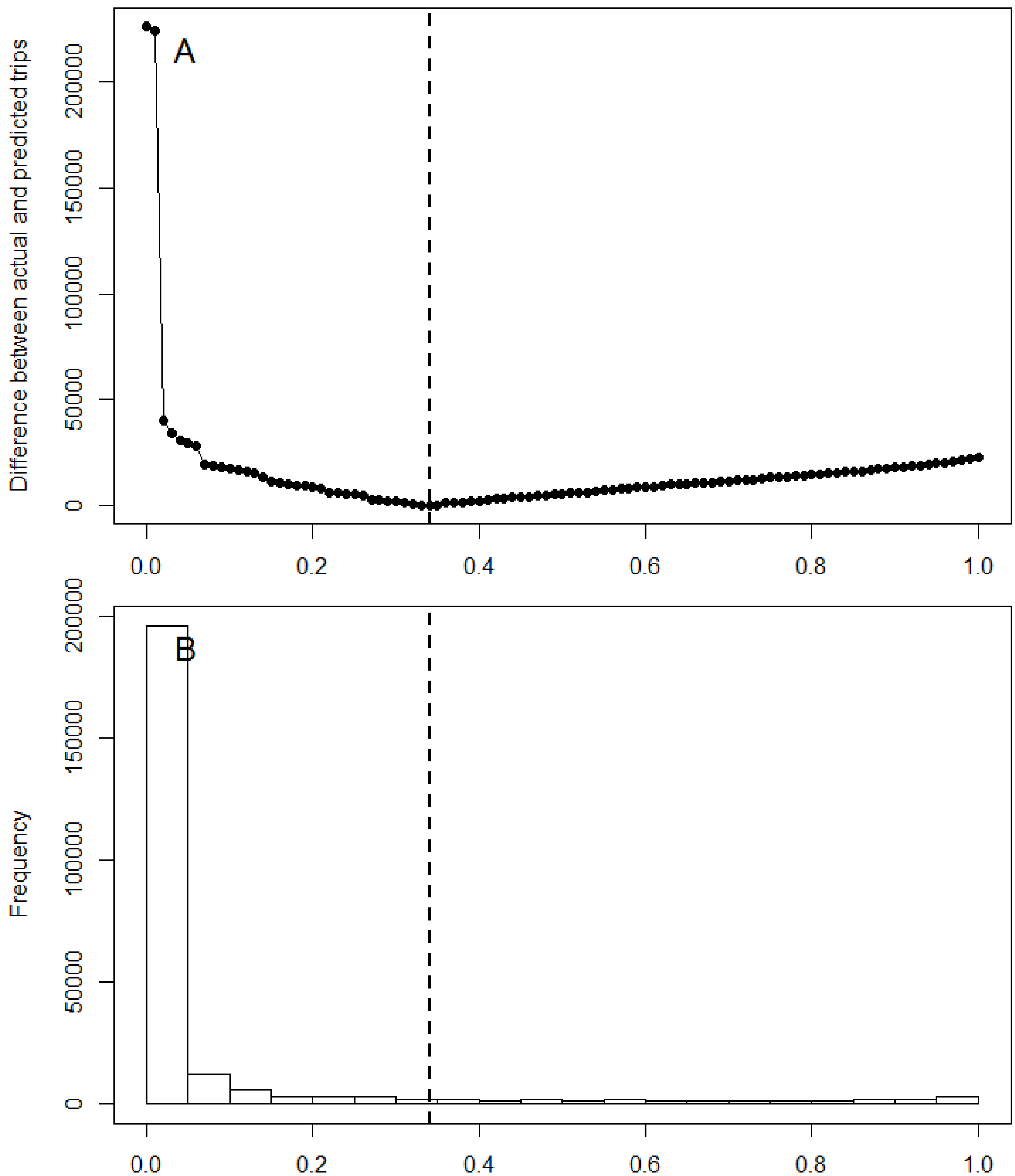


Figure 1. The difference between the number of records in the Western U.S. Gulf of Mexico in which Vermilion Snapper are observed and the number in which they are predicted to occur for each probability threshold (A). Histogram of probabilities generated by the species-based regression (B). The dashed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

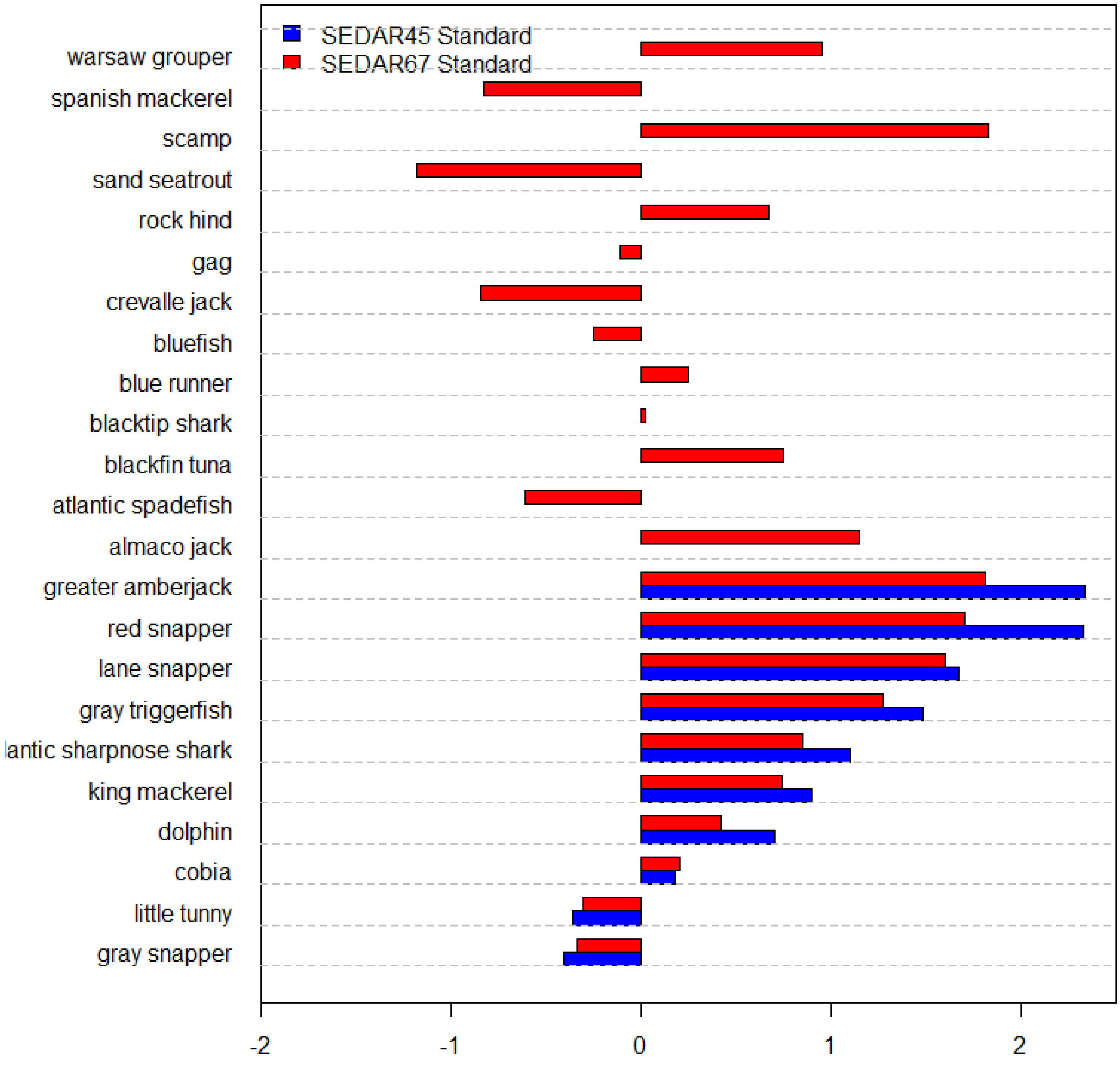


Figure 2. Comparison of coefficients obtained from the Stephens and MacCall (2004) trip selection approach for SEDAR67 and the previous SEDAR45 assessment in the Western U.S. Gulf of Mexico.

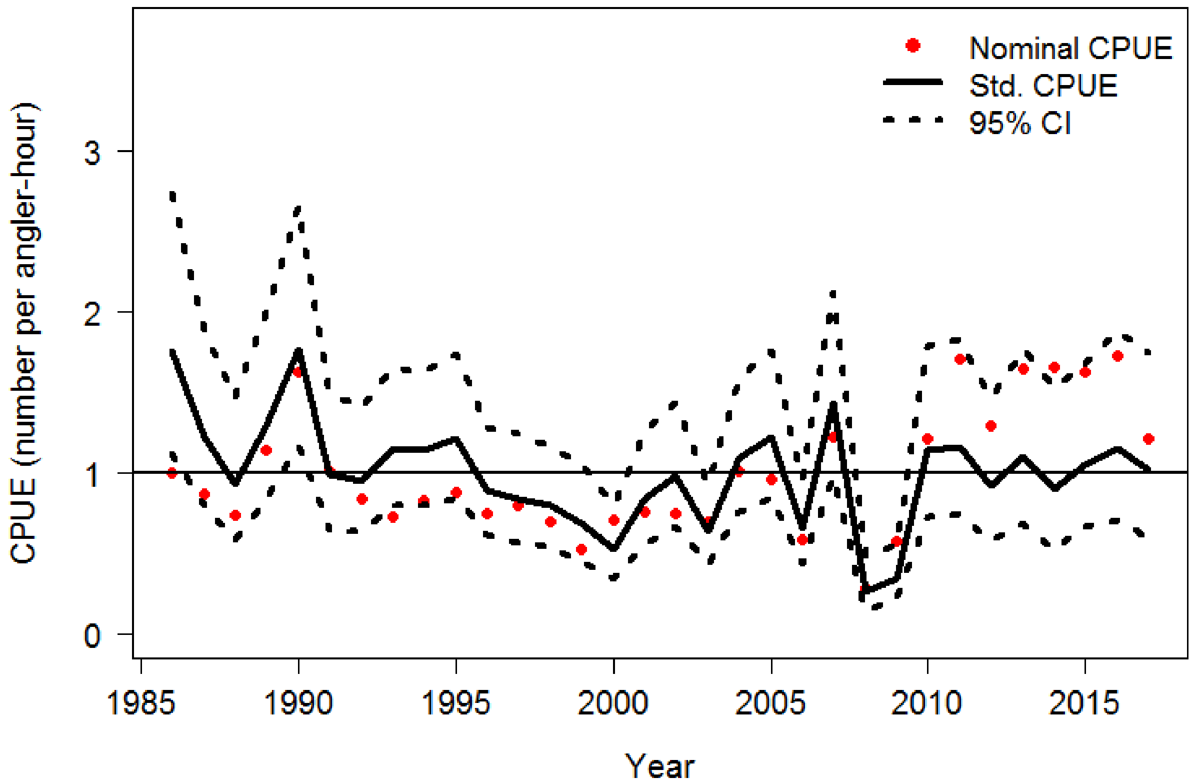


Figure 3. Standardized indices with 95% confidence intervals and nominal CPUE for Vermilion Snapper in the Western U.S. Gulf of Mexico.

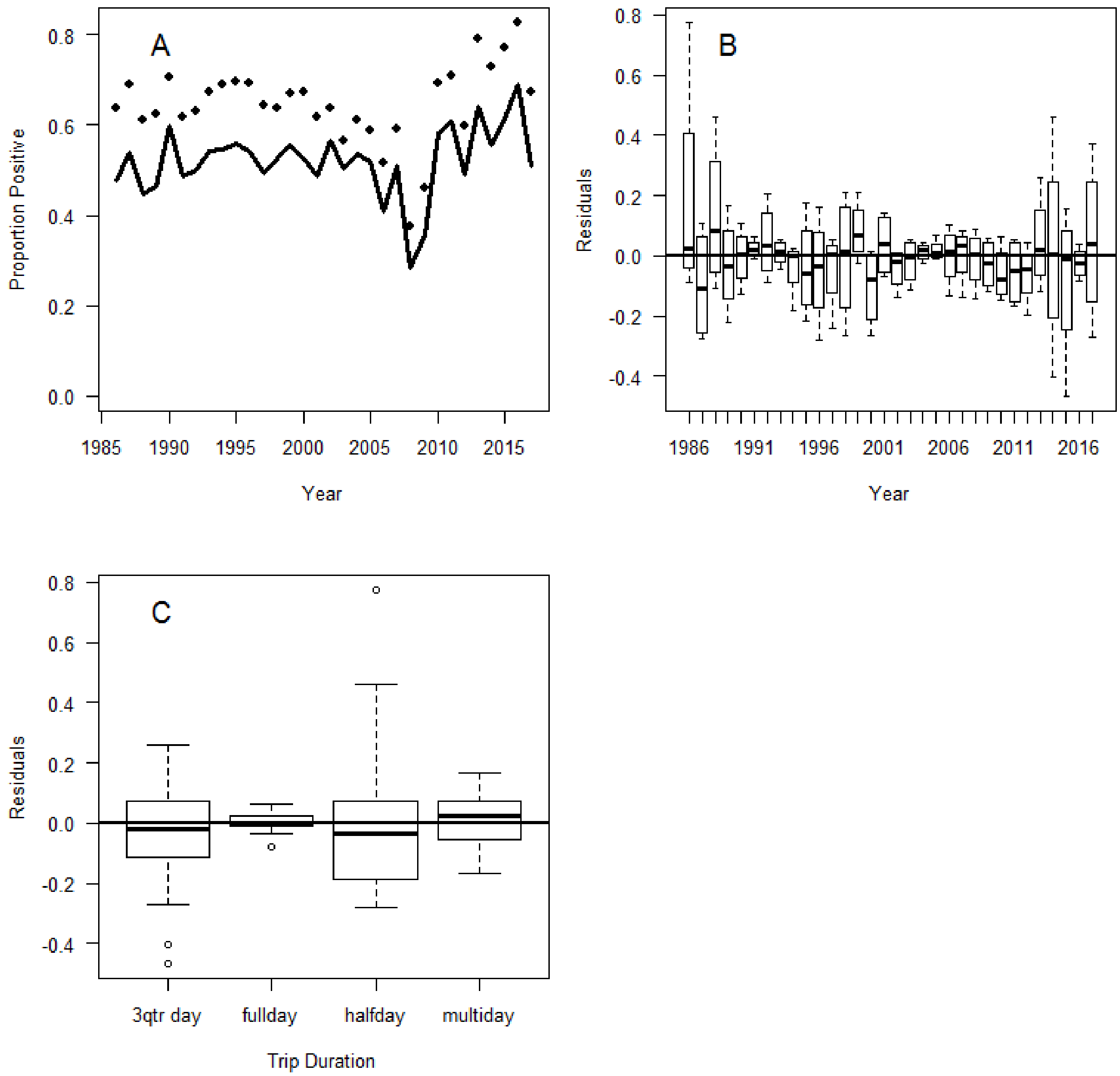


Figure 4. Diagnostic plots for the binomial model for Vermilion Snapper in the Western U.S. Gulf of Mexico. Shown here are the predicted (solid line) and observed proportion of positive trips by year (A), and the residuals from the binomial model by year (B) and trip duration(C).

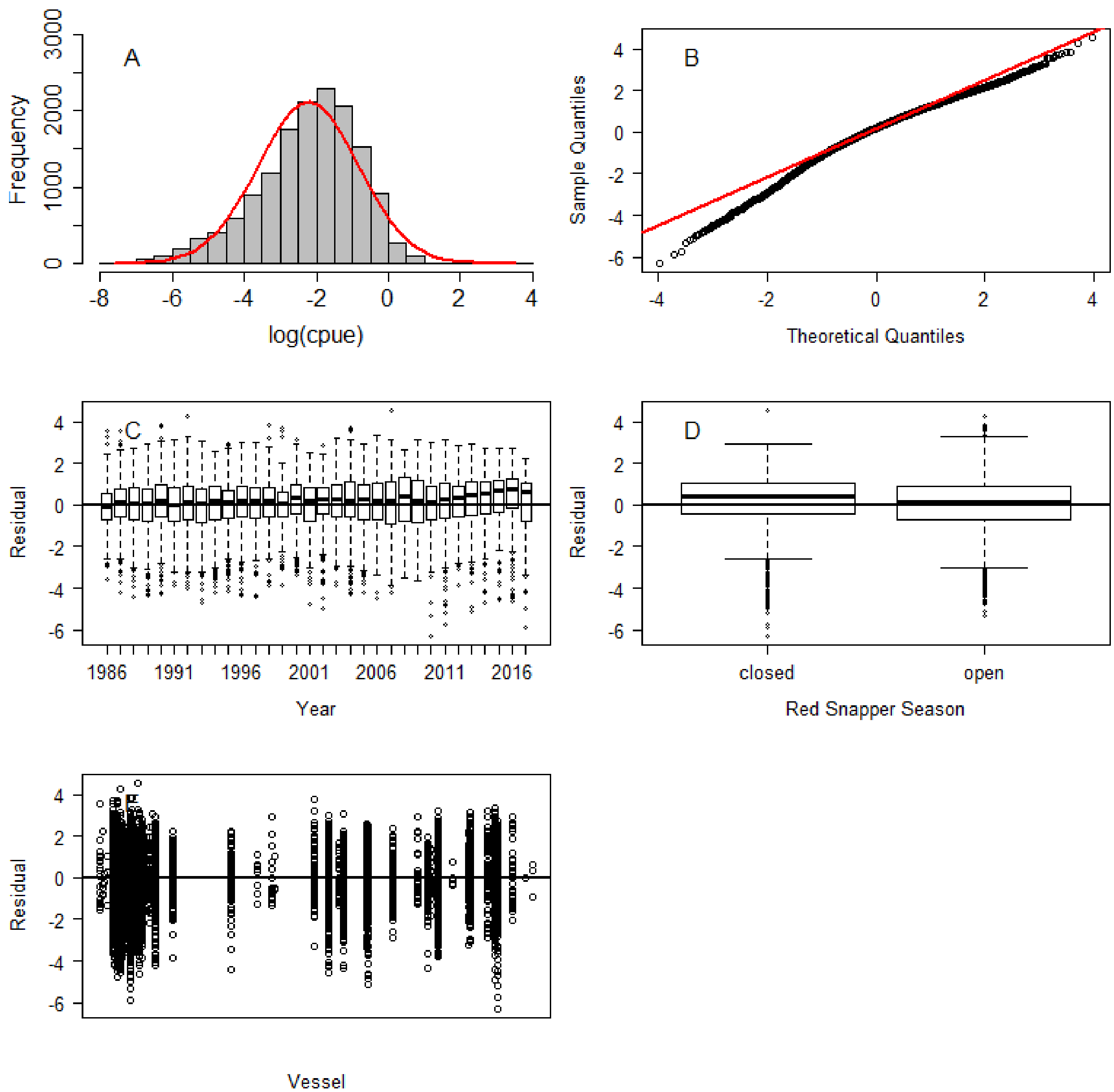


Figure 5. Diagnostic plots for the lognormal model of catch rates on positive trips for Vermilion Snapper in the Western U.S. Gulf of Mexico. Shown here are the frequency distribution of catch rates (A), the cumulative normalized residuals (B), and the distribution of residuals by year (C), red snapper season (D) and vessel (E). The red lines represent the expected normal distribution. Note vessel numbers have been excluded due to confidentiality.

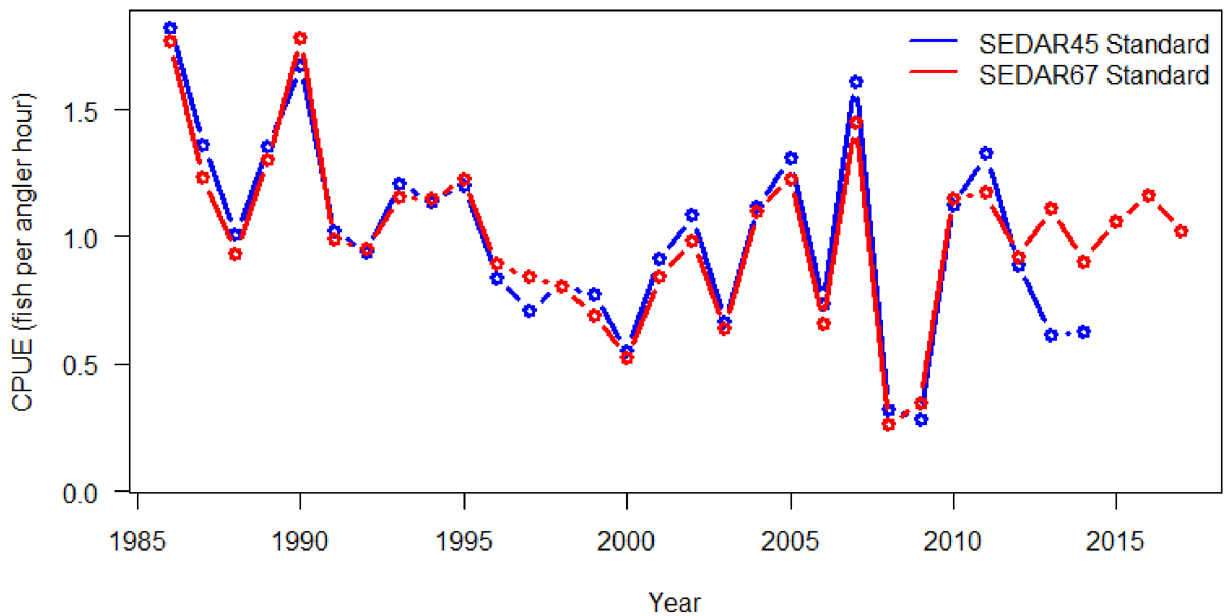


Figure 6. Standardized index for Vermilion Snapper in the Western U.S. Gulf of Mexico for SEDAR67 compared to the index provided during SEDAR45. For comparison, both indices have been normalized by their respective means.

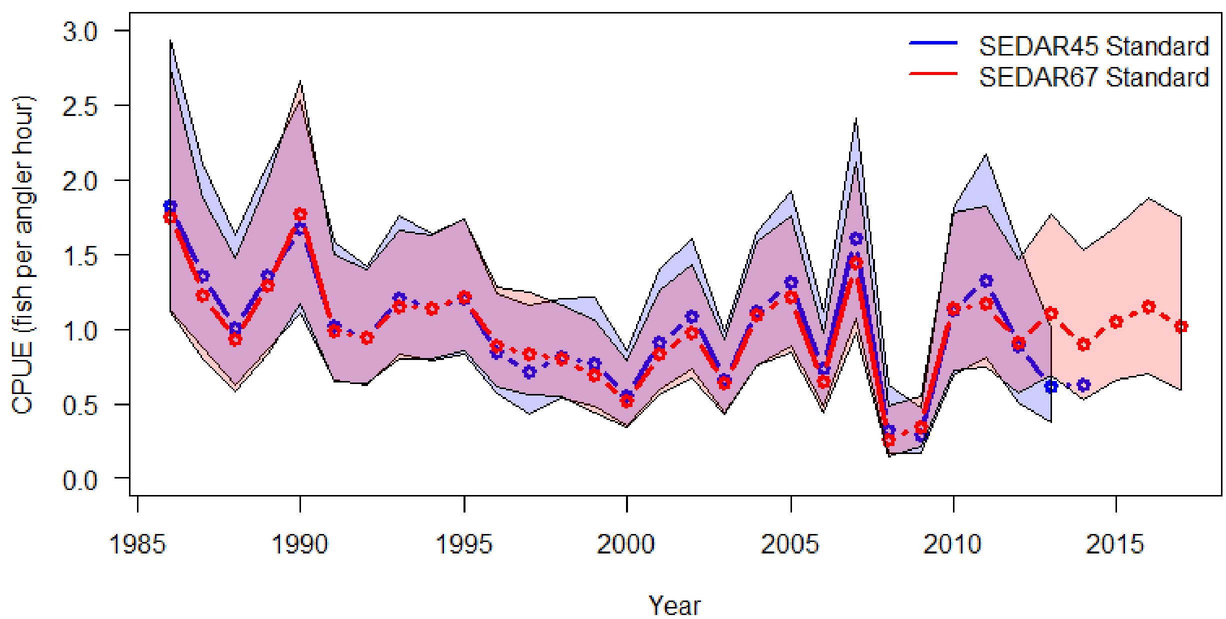


Figure 7. Comparison of index for Vermilion Snapper in the Western U.S. Gulf of Mexico for SEDAR67 compared to the index provided during SEDAR45 with confidence intervals.

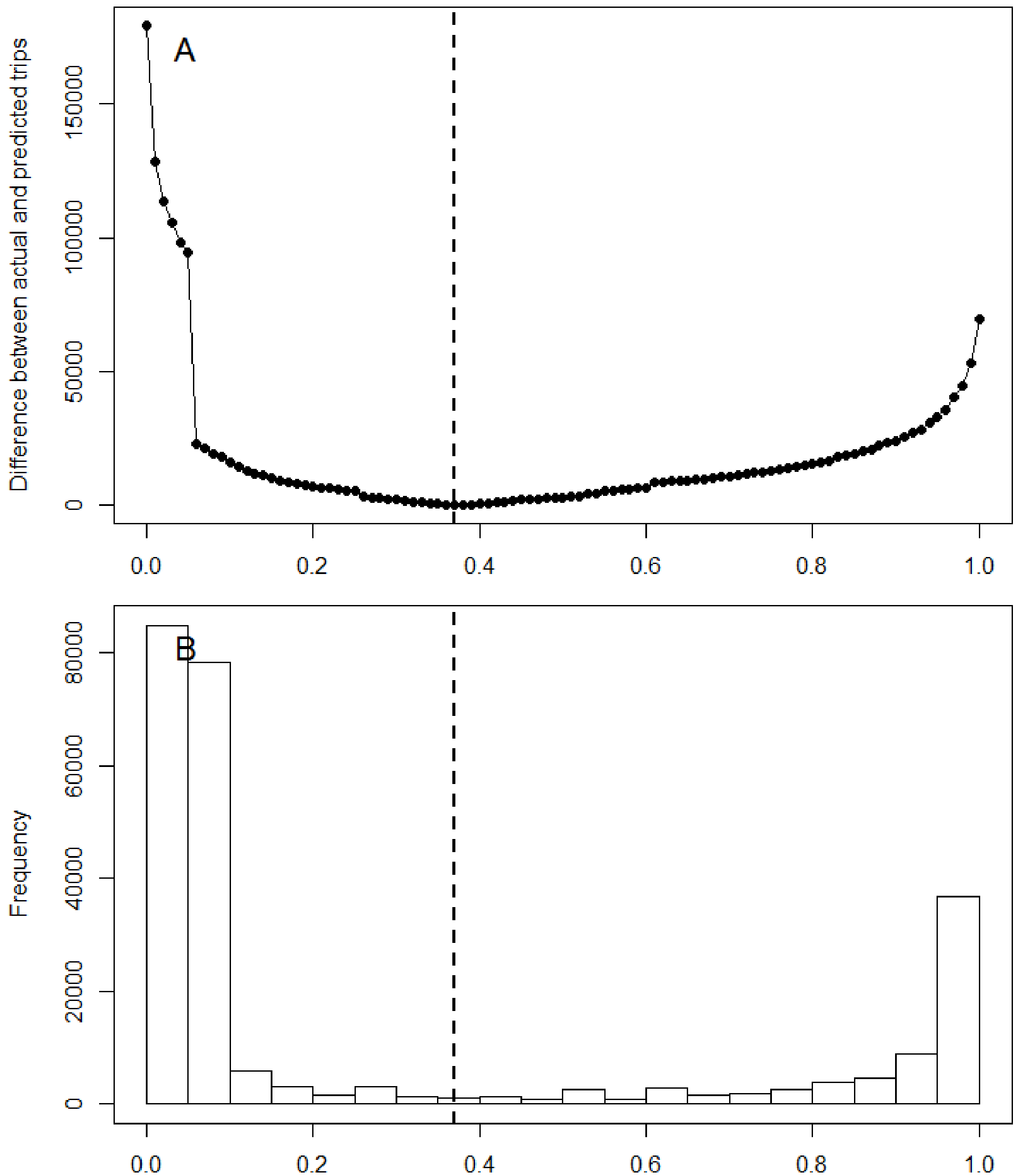


Figure 8. The difference between the number of records in the Eastern U.S. Gulf of Mexico in which Vermilion Snapper are observed and the number in which they are predicted to occur for each probability threshold (A). Histogram of probabilities generated by the species-based regression (B). The dashed vertical line indicates the critical value where false prediction is minimized.

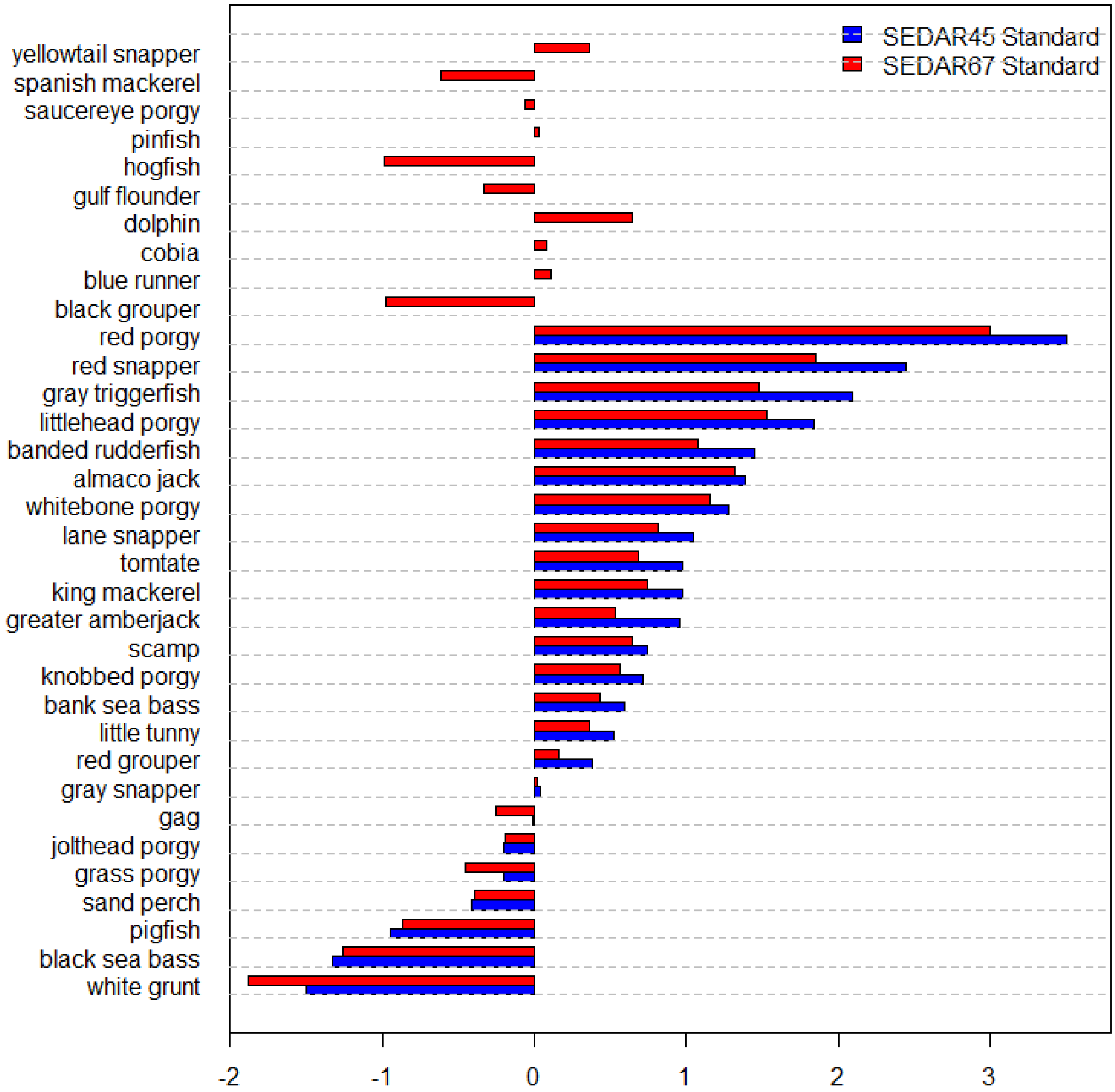


Figure 9. Comparison of coefficients obtained from the Stephens and MacCall (2004) trip selection approach for SEDAR67 and the previous SEDAR45 assessment in the Eastern U.S. Gulf of Mexico.

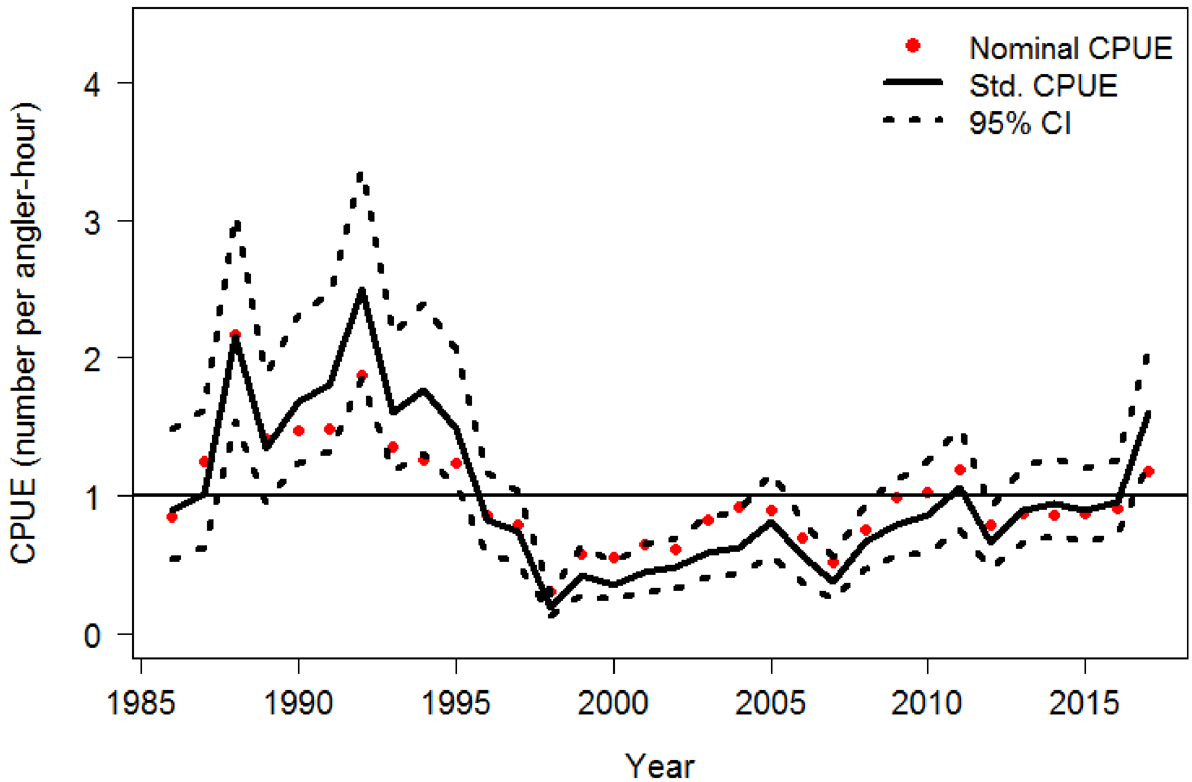


Figure 10. Standardized indices with 95% confidence intervals and nominal CPUE for Vermilion Snapper in the Eastern U.S. Gulf of Mexico.

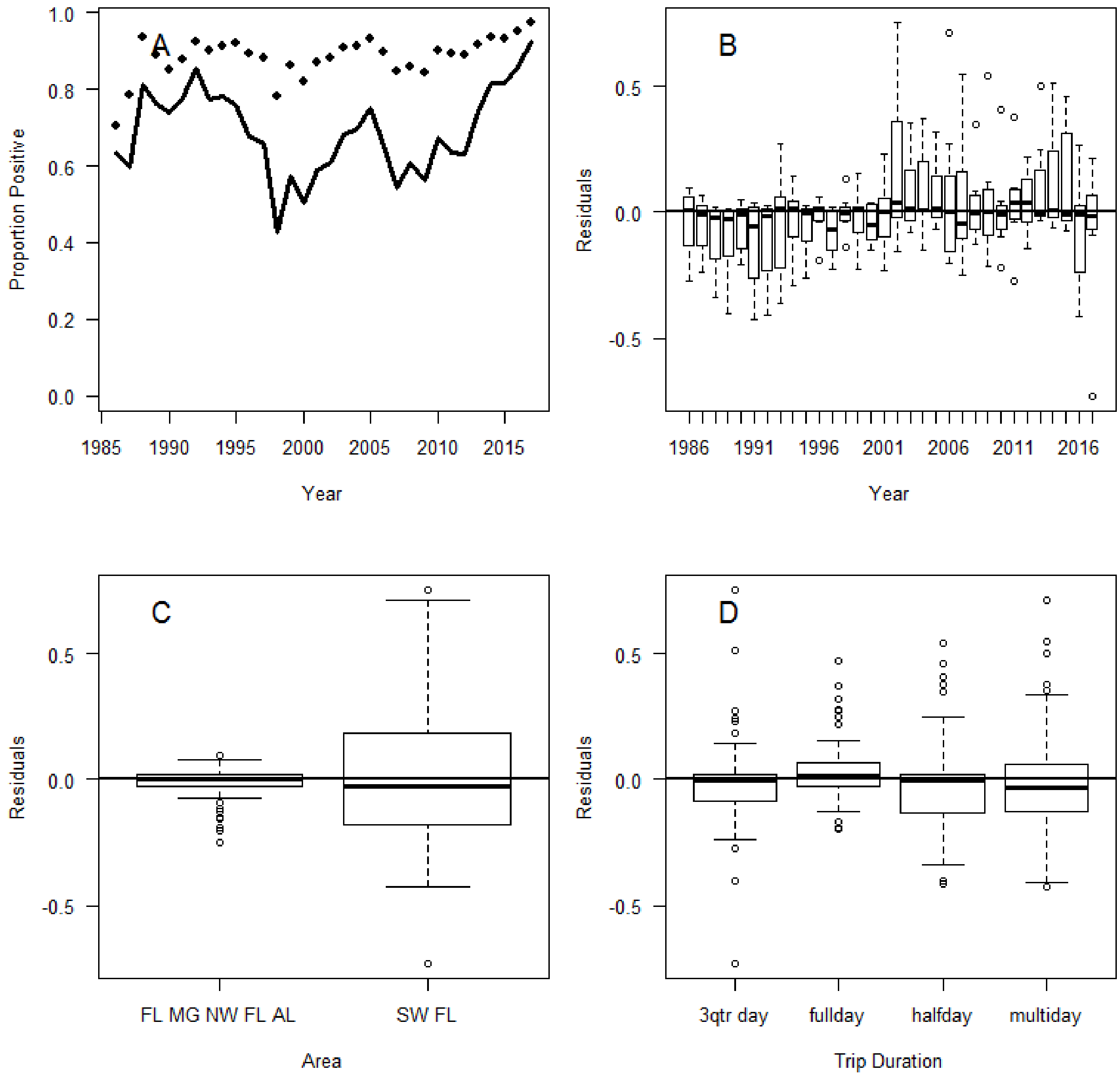


Figure 11. Diagnostic plots for the binomial model for Vermilion Snapper in the Eastern U.S. Gulf of Mexico. Shown here are the predicted (solid line) and observed proportion of positive trips by year (A), and the residuals from the binomial model by year (B), area (C) and trip duration (D).

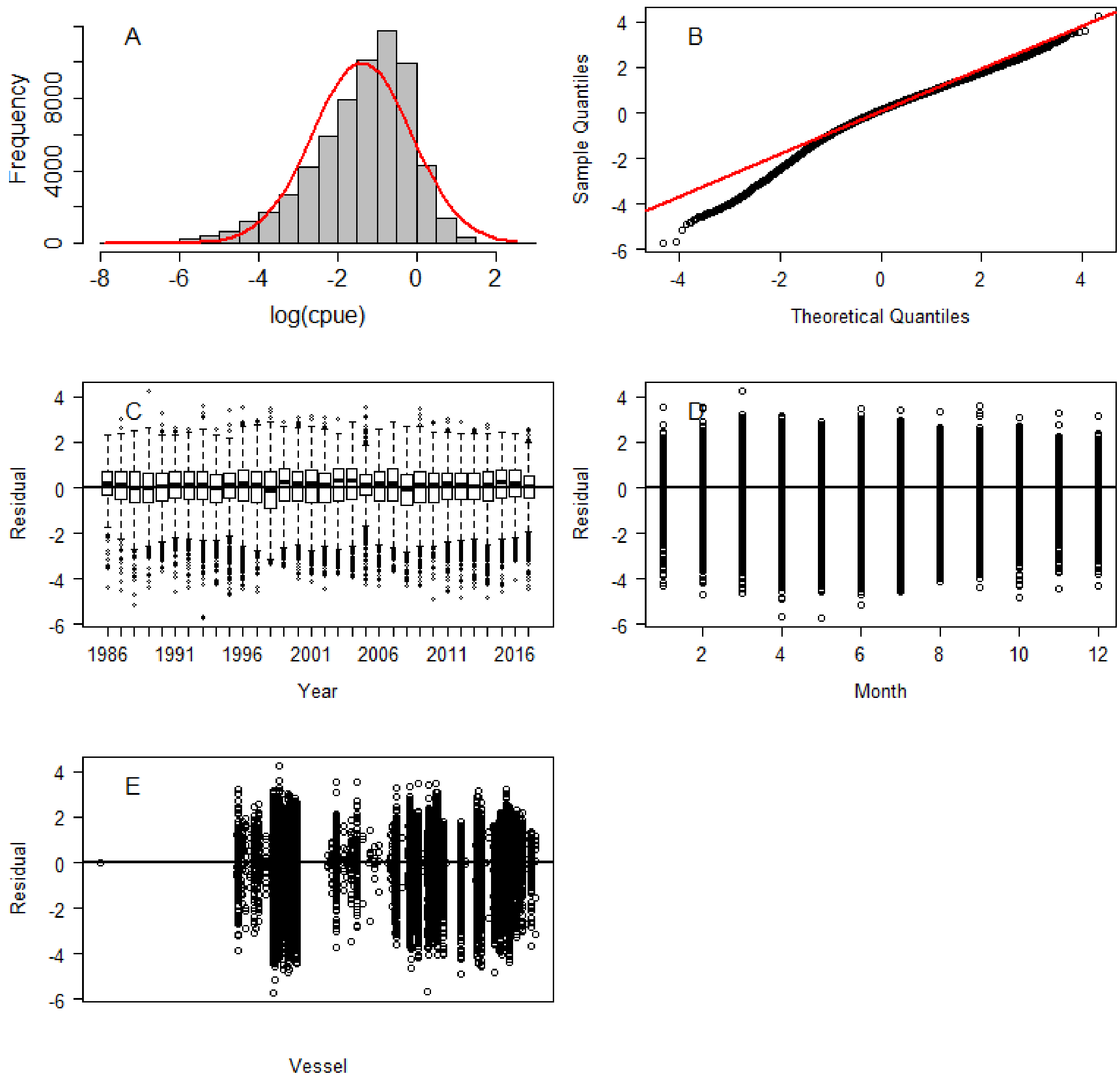


Figure 12. Diagnostic plots for the lognormal model of catch rates on positive trips for Vermilion Snapper in the Eastern U.S. Gulf of Mexico. Shown here are the frequency distribution of catch rates (A), the cumulative normalized residuals (B), and the distribution of residuals by year (C), month (D) and vessel (E). The red lines represent the expected normal distribution. Note vessel numbers have been excluded due to confidentiality.

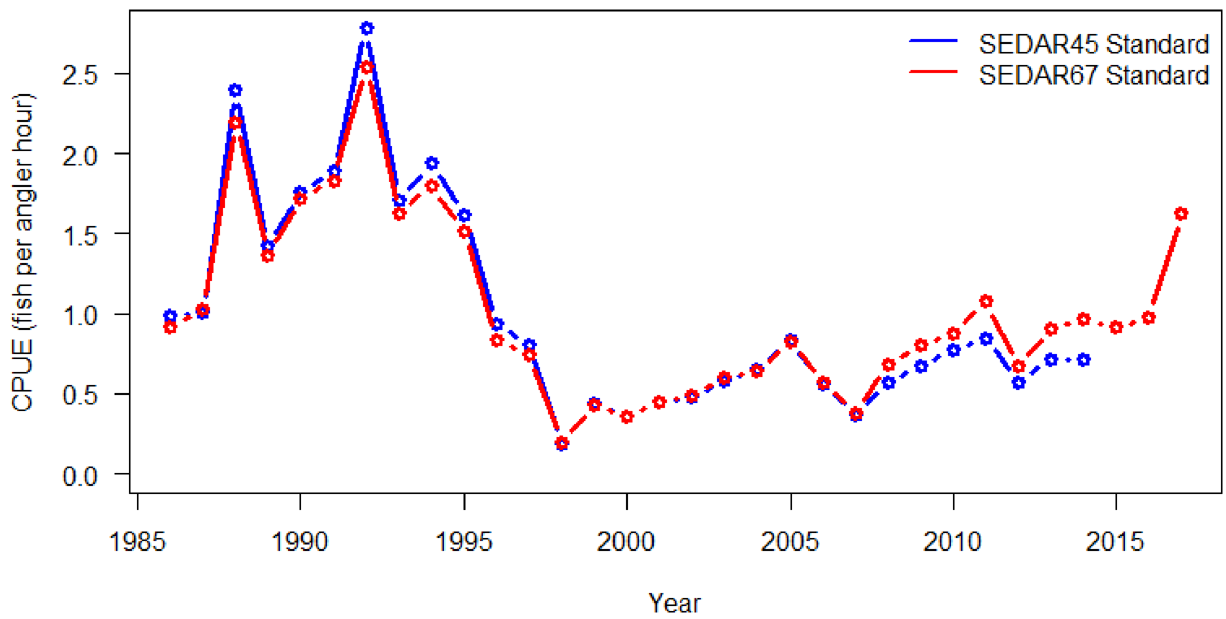


Figure 13. Standardized index for Vermilion Snapper in the Eastern U.S. Gulf of Mexico for SEDAR67 compared to the index provided during SEDAR45. For comparison, both indices have been normalized by their respective means.

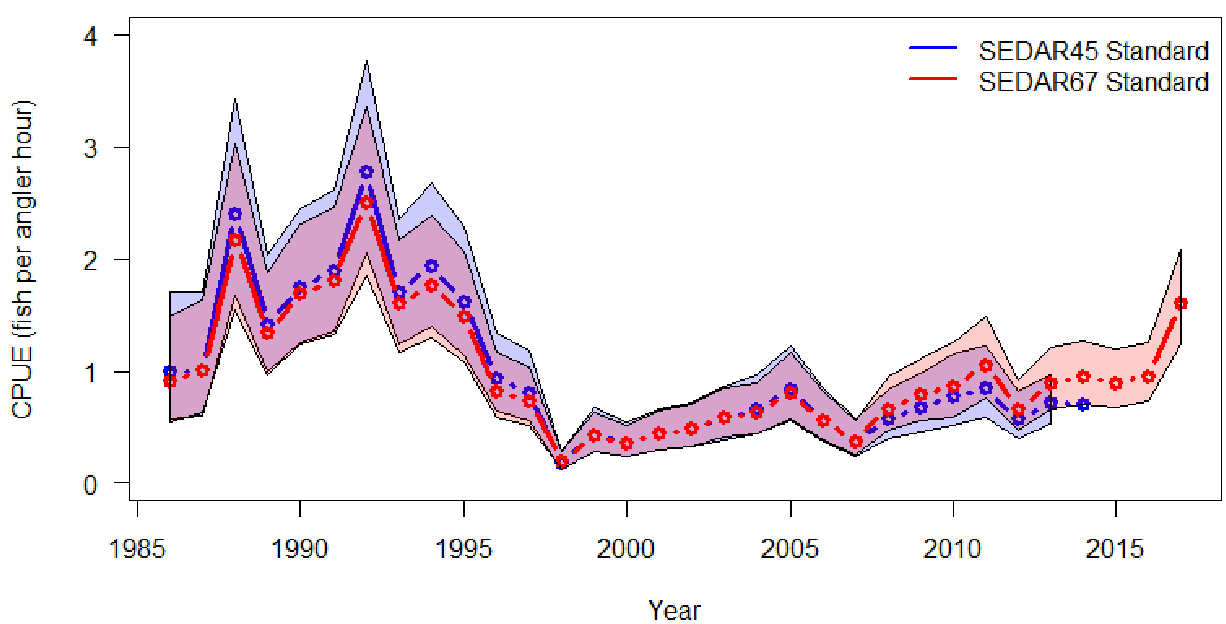


Figure 14. Comparison of index for Vermilion Snapper in the Eastern U.S. Gulf of Mexico for SEDAR67 compared to the index provided during SEDAR45 with confidence intervals.