Standardized catch rates for greater amberjack from the Gulf of Mexico headboat fishery during 1986-2010

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Standardized Catch Rates for Greater Amberjack from the Gulf of Mexico Headboat Fishery 1986-2012

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INTRODUCTION

The recreational fishery in the Gulf of Mexico is surveyed by the Marine Recreational Fishery Statistics Survey (MRFSS) conducted by NOAA Fisheries, the Texas Marine Sport-Harvest Monitoring Program conducted by the Texas Parks and Wildlife Department (TPWD), and the Headboat Survey (HBS) conducted by NOAA Fisheries. The HBS has monitored catch and effort from party (head) boats in the Gulf of Mexico since 1986. The purpose of this report is to outline the development of a standardized index of abundance for Gulf of Mexico greater amberjack using the HBS data.

METHODS

Headboat Survey

The HBS collects catch and effort data for individual headboat trips. Specific information such as the number of anglers, vessel identification, fishing area, trip type/duration (half, three-quarter, full, and multi-day trips), approximate time of day of fishing, fishing date, and catch by species in number and weight are collected as part of this program.

HBS data were used to characterize abundance trends of greater amberjack in the Gulf of Mexico. Catch per unit effort (CPUE) was calculated on an individual trip basis. CPUE was equal to the number of greater amberjack landed on a given trip divided by the effort, where effort was the product of the number of anglers and the total hours fished. A half-day fishing trip was assumed to be 5 hours, a three-quarter day trip was assumed to be seven hours, and a full-day trip was assumed to be 10 hours. A fishing day was assumed to be 12 hours for multi-day trips. Many individuals fish aboard headboats; therefore, total effort per trip was calculated as the product of the reported number of anglers and the assumed hours fished.

Data preparation and filtering

The following data preparation and filtering techniques were applied to the HBS dataset:

1. Only full-day trips were retained.
2. HBS observations in the Gulf of Mexico were classified into three regions.
3. Selected trips that reached bag limits for greater amberjack were retained.
4. Trips during the closed season for greater amberjack were excluded.
5. Data from 2010 were excluded.
6. The Stephens MacCall (2004) approach was used to restrict the dataset to those trips that targeting greater amberjack.

The HBS dataset was looked at across different strata to assess the sample size of total trips and successful trips (trips that reported having caught greater amberjack) within each of the strata. Although reported headboat trips ranged in length from half a day to multiple days, trip length was observed to be confounded with region. For example, full day trips made up 93.2% of all trips in the NW TX region. Therefore, only full day trips were included in the analysis.

In the SEDAR9 benchmark and update assessments, HBS observations in the Gulf of Mexico were classified into five regions. The five regions were: 1) central and southwest Florida, 2) northwest Florida and Alabama, 3) Louisiana, 4) northeast Texas, and 5) central and south Texas. Since the Louisiana and central and southwest Florida regions each had multiple years without any positive trips, the 5 regions were aggregated into only 3 regions by taking into account geographic proximity and individual trends in CPUE over time. The regions used in this analysis were: 1) Florida, Alabama, and Louisiana, 2) northeast Texas, and 3) central and south Texas.

The management of greater amberjack is done by size limits, bag limits, and fishing seasons. The HBS data were explored to determine the number of trips that reached the cumulative bag limit. Between 1990 and 1996, when the bag limit was three fish per person per day, only 0.17% of positive trips either reached or exceeded the bag limit for greater amberjack. Between 1997 and 2012, when the bag limit was one fish per person per day, 2.76% of positive trips reached the bag limit while 0.93% of positive trips exceeded the bag limit. Given so few trips reached the bag limit, they were left in the database for analysis.

Fishing behavior was assumed to have been altered by the implementation of opened and closed seasons (see SEDAR33-RD05 for the management history of greater amberjack). Trips during the closed fishing seasons in 2011, and 2012 were removed from this analysis.

In 2010, there were significant area closures in the Gulf of Mexico from May to November that were related to the Deepwater Horizon/BP Oil Spill (SERO 2013). Total trips, total positive trips, and total landings from the FL, AL, and LA region during the summer (May - July) of 2010 declined by 48%, 81%, and 90%, respectively, as compared to mean values over the previous three summers (2007-2009). As such, catch rates reported in the FL, AL, and LA region during the 2010 area closures may reflect temporary shifts in targeting and catchability. Since changes in headboat fishing behavior in response to the 2010 area closures are not accounted for in the standardization procedure, data from 2010 were excluded from the analysis.

Headboat trips can target any number of species on any given trip; therefore, species targeting is generally unknown. The Stephens-McCall approach (2004) was used to identify trips that targeted greater amberjack. This approach uses the species composition of each trip in a logistic regression of species presence/absence to infer if effort on that trip occurred in similar habitat to greater amberjack habitat. If effort on a trip was determined to occur in similar habitat to greater amberjack, or if a trip caught only greater amberjack, then that trip was used in the analysis.

Standardization

Delta-lognormal modeling methods were used to estimate a relative index of abundance for greater amberjack (Lo et al. 1992). The main advantage of using this method is allowance for the probability of zero catch (Ortiz et al. 2000). The delta-lognormal modeling approach combines separate generalized linear model (GLM) analyses of the proportion of successful trips (trips that landed greater amberjack) and of the catch rates on successful trips to construct a single standardized CPUE index (Lo et al. 1992, Hinton and Maunder 2004, Maunder and Punt 2004).

For each GLM procedure of proportion positive trips, a type-3 model assuming a binomial error distribution was assumed and the logit link was selected. The response variable was the proportion of successful trips across strata. For the analysis of the catch rates on successful trips, a type-3 model assuming lognormal error distribution was examined. A "normal" linking function was selected and the response variable was calculated as the natural log of CPUE.

A stepwise approach was used to quantify the relative importance of the explanatory factors. First, a GLM model was fit to the null model (only the intercept) and the AIC, deviance and degrees of freedom were calculated. Next, a suite of models was tested where each potential explanatory factor was added to the null model. Again, the AIC, deviance, and degrees of freedom were calculated. The model with the factor that had the lowest AIC became the new base model and the process was repeated by adding factors individually until either the AIC was no longer further reduced or the all the factors were added to the model. In addition to screening using AIC, factors were also screened and not added to the model if the reduction in deviance per degree of freedom was less than one percent. This screening was implemented in order to fit a more parsimonious model, given the fact that factors which reduce the deviance by so little exert little influence on the index trend.

Two-way interactions among significant main effects were examined. YEAR*FACTOR interaction terms were included in the model as random effects. The final delta-lognormal model was fit using a SAS macro, GLIMMIX (Russ Wolfinger, SAS Institute). To facilitate visual comparison, a relative standardized index and relative nominal CPUE series were calculated by dividing each value in the series by the mean value of the entire time-series.

The following factors were examined as possible influences on the proportion of positive trips, and on the catch rates of trips reporting the capture of greater amberjack:

FACTOR	LEVELS	DESCRIPTION
YEAR	26	1986-2009 and 2011-2012
REGION	3	Central and South West TX (Area codes 26-27), Northwest TX (Area codes 25), FL, AL, and LA (Area codes 21-22-23-24)
SEASON	4	Nov-Jan, Feb-Apr, May-July, Aug-Oct
NUMBER OF ANGLERS (binomial component only)	8	Bins for number anglers: 1-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71+

Results and discussion

The Stephens-MacCall approach was used to identify trips that targeted greater amberjack. The left panel of Figure 1 shows the critical probability which minimizes the difference between the predicted number and the observed number of trips greater amberjack. The right panel of Figure 1 shows the frequency of trips associated with the critical probability. Given these diagnostics, sufficient trips were retained in the database to develop a standardized index of abundance.

Various factors and first level interactions were tested for significance using the stepwise approach and accordingly included or excluded from the model. The following models resulted from the standardization procedures where *Success* is a binomial indicating whether or not a group of anglers caught greater amberjack, α represents the parameter estimate of each factor, μ represents the mean, and ε represents the error term.

$$Success = \mu + (Year)\alpha_1 + (Region)\alpha_2 + (Year * Region)\alpha_3 + \varepsilon$$
$$\ln(CPUE) = \mu + (Year)\alpha_1 + (Region)\alpha_2 + (Season)\alpha_3 + (Year * Region)\alpha_4 + \varepsilon$$

Although the interaction term between Year and Region was included in the binomial deviance analysis and in the GLM exercise, this interaction was not included in the final binomial model because the model would not converge.

Table 2 summarizes the standardized index and corresponding coefficients of variation, upper confidence limits, lower confidence limits, and nominal CPUE. Final deviance tables are included in Table 3.

Results for the greater amberjack headboat index standardization show that the highest value was at the start of the time series in 1986 and was followed by an overall decline through 1990. The index increased until 1992, declined until 1994, and then remained relatively stable through 2000. After 2000, the index increased until 2003 and then declined until 2005. The most recent years of the time series are marked by a brief and potentially spurious peak centered in 2008. In the last two years of the time series the index is stable (Figure 2).

The headboat index developed here for the SEDAR 33 assessment has similar trends as the headboat indices developed for the SEDAR9 benchmark and update assessments (Figure 3).

Acknowledgements

The author thanks Meaghan Bryan, Steve Saul, Kevin McCarthy, and Allison Shideler for their assistance and advice.

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Tables

Table 1. Stephens and MacCall regression coefficients for species occurring in at least 1% of headboat trips in the Gulf of Mexico.

Species	Species Code	Estimate	Std. Error	z value	Pr(>|z|)
Vermilion Snapper	sp10	1.03	0.03	38.87	<0.0001
Cobia	sp55	0.82	0.03	28.79	<0.0001
Scamp	sp30	0.69	0.03	23.03	<0.0001
Warsaw Grouper	sp23	0.43	0.04	11.46	<0.0001
Gray Snapper	sp18	0.30	0.03	11.21	<0.0001
Tomtate	sp51	0.15	0.04	3.87	0.0001
Little Tunny	sp116	0.13	0.03	3.80	0.0001
Red Snapper	sp11	0.03	0.03	1.09	0.2737
King Mackerel	sp74	0.01	0.02	0.27	0.7845
Gag Grouper	sp29	-0.01	0.03	-0.43	0.6641
Dolphin	sp117	-0.08	0.04	-2.22	0.0265
Lane Snapper	sp16	-0.12	0.02	-5.02	<0.0001
Gray Triggerfish	sp77	-0.14	0.03	-5.53	<0.0001
Red Grouper	sp22	-0.14	0.04	-4.03	0.0001
Atlantic Sharpnose Shark	sp230	-0.26	0.03	-8.61	<0.0001
Black Sea Bass	sp33	-0.58	0.08	-7.52	<0.0001
Red Porgy	sp1	-0.64	0.03	-18.77	<0.0001
White Grunt	sp50	-1.03	0.05	-20.71	<0.0001
Intercept	Intercept	-1.74	0.03	-54.94	<0.0001

Table 2. Gulf of Mexico greater amberjack standardized index values, coefficients of variation, upper confidence limits, lower confidence limits, and nominal CPUE values from the headboat fishery.

Year	Standardized Index	CV	Lower 95% CI	Upper 95% CI	Nominal CPUE
1986	3.546	0.350	1.797	6.997	3.408
1987	1.774	0.384	0.845	3.724	1.778
1988	1.905	0.372	0.928	3.913	2.263
1989	1.493	0.385	0.710	3.139	1.494
1990	0.576	0.454	0.242	1.370	0.752
1991	0.728	0.433	0.318	1.668	0.791
1992	1.213	0.386	0.576	2.554	1.320
1993	0.735	0.401	0.340	1.591	0.641
1994	0.577	0.423	0.257	1.298	0.466
1995	0.681	0.416	0.306	1.513	0.534
1996	0.778	0.407	0.355	1.704	0.761
1997	0.597	0.446	0.255	1.399	0.526
1998	0.409	0.469	0.167	0.997	0.309
1999	0.547	0.493	0.215	1.390	0.576
2000	0.521	0.486	0.208	1.308	0.384
2001	0.916	0.426	0.405	2.073	0.878
2002	1.059	0.441	0.456	2.462	0.993
2003	1.425	0.417	0.640	3.172	1.230
2004	1.084	0.417	0.487	2.413	0.906
2005	0.482	0.470	0.197	1.179	0.389
2006	0.692	0.476	0.280	1.710	0.552
2007	0.420	0.486	0.167	1.054	0.436
2008	1.506	0.496	0.589	3.846	1.858
2009	0.729	0.445	0.311	1.705	0.987
2010					
2011	0.865	0.540	0.314	2.381	0.898
2012	0.742	0.537	0.271	2.031	0.869

Table 3. Final deviance tables for the Gulf of Mexico greater amberjack regressions from the headboat fishery. 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. Although the interaction term between Year and Region (highlighted in gray) was included in the binomial deviance analysis and in the GLM exercise, this interaction was not included in the final model because it did not converge.

Binomial								
Factor	**DF**	**Deviance**	**Residual Df**	**Residual Deviance**	**AIC**	**% Deviance Reduced**	**Log likelihood**	**Likelihood Ratio Test**
Null	1	17001.60	12418	17001.60	17001.60	-	-8500.80	-
Year	25	16371.30	12393	630.30	16371.20	3.71	-8185.60	630.40
Region	2	16208.20	12391	163.10	16208.20	1.00	-8104.10	163.00
Year*Region	50	15691.00	12341	517.20	15691.00	3.19	-7845.50	517.20
Lognormal								
Factor	**DF**	**Deviance**	**Residual Df**	**Residual Deviance**	**AIC**	**% Deviance Reduced**	**log likelihood**	**Likelihood Ratio Test**
Null	1	63799.50	12418	63799.50	55567.60	-	-27783.80	-
Region	2	62307.50	12416	1492.00	55273.60	2.34	-27636.80	294.00
Year	25	60905.70	12391	1401.80	54991.00	2.25	-27495.50	282.60
Season	3	60238.60	12388	667.10	54854.20	1.10	-27427.10	136.80
Year*Region	50	58777.20	12338	2128.50	54549.20	2.43	-27274.60	441.80

FIGURES

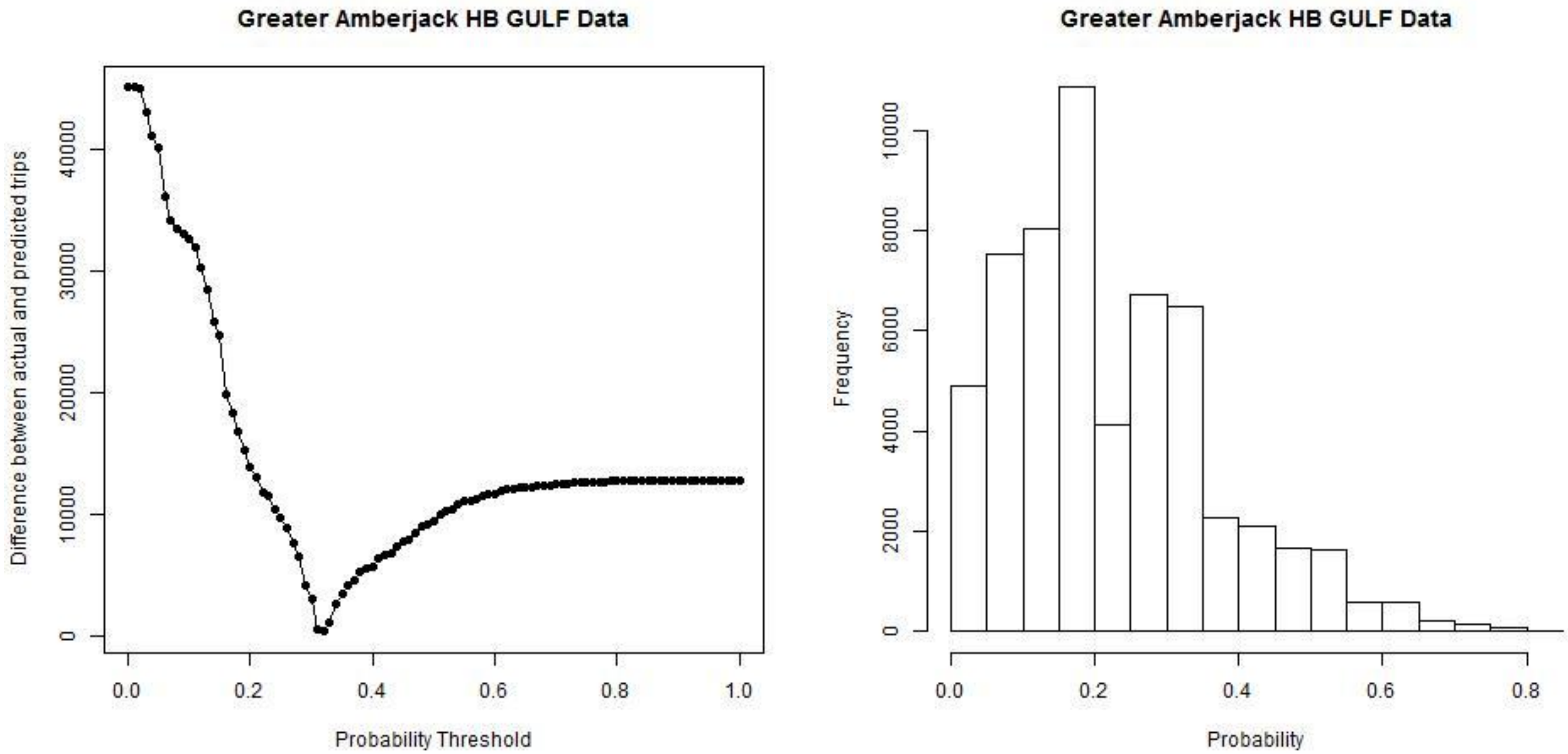

Figure 1. The left panel shows the difference between the number of records in which greater amberjack were observed and the number in which they were predicted. A critical value of 0.32 minimizes the difference. The right panel shows a histogram of the frequency of probabilities generated by the species regression.

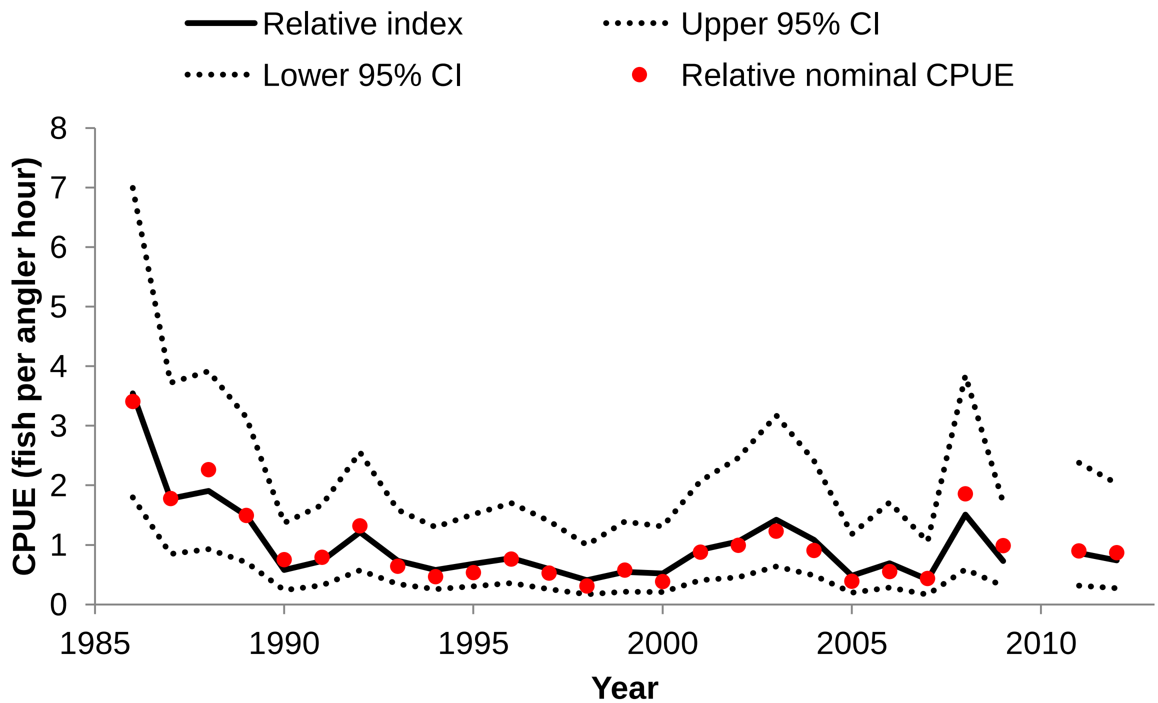

Figure 2. Nominal CPUE, standardized index, and the 95% confidence intervals for the Gulf of Mexico greater amberjack from the headboat fishery. The standardized index and nominal CPUE values were normalized by their respective means over the time series.

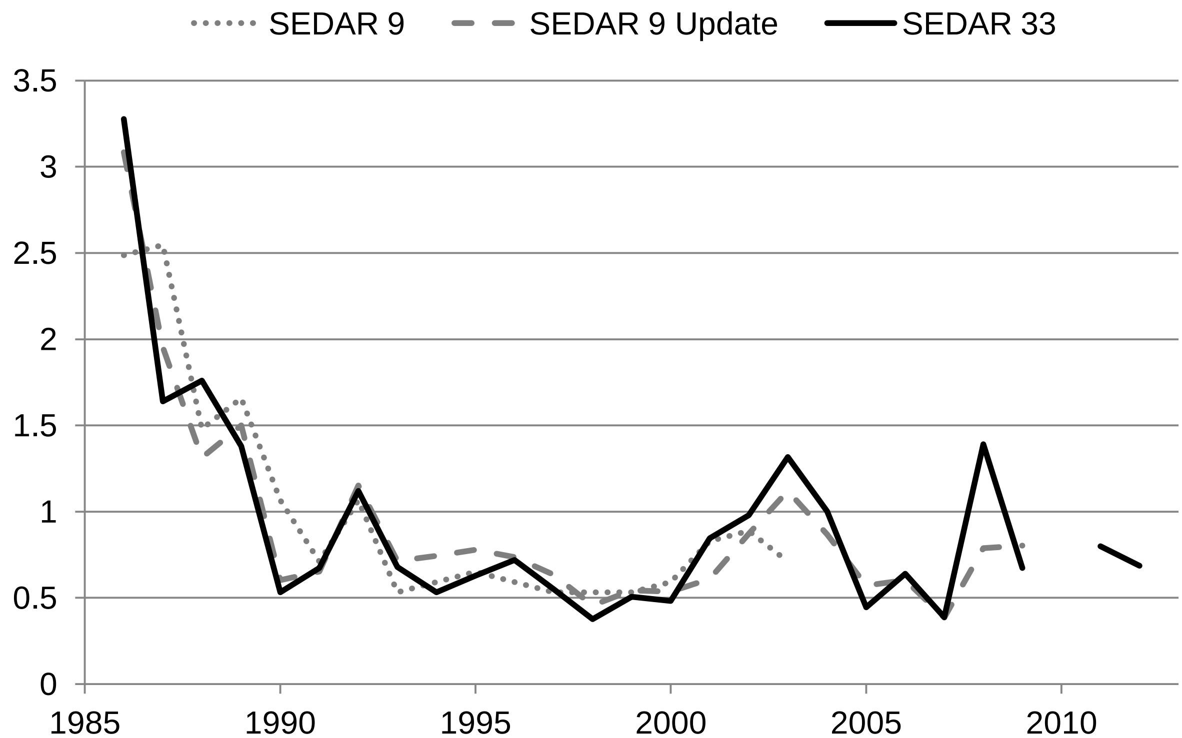

Figure 3. Standardized headboat indices for Gulf of Mexico greater amberjack from the current assessment (SEDAR 33) and from previous assessments (SEDAR 9 and the SEDAR 9 update). Indices were normalized by their respective means during the overlapping period.

Appendix A: Diagnostic plots for the headboat index of Gulf of Mexico greater amberjack

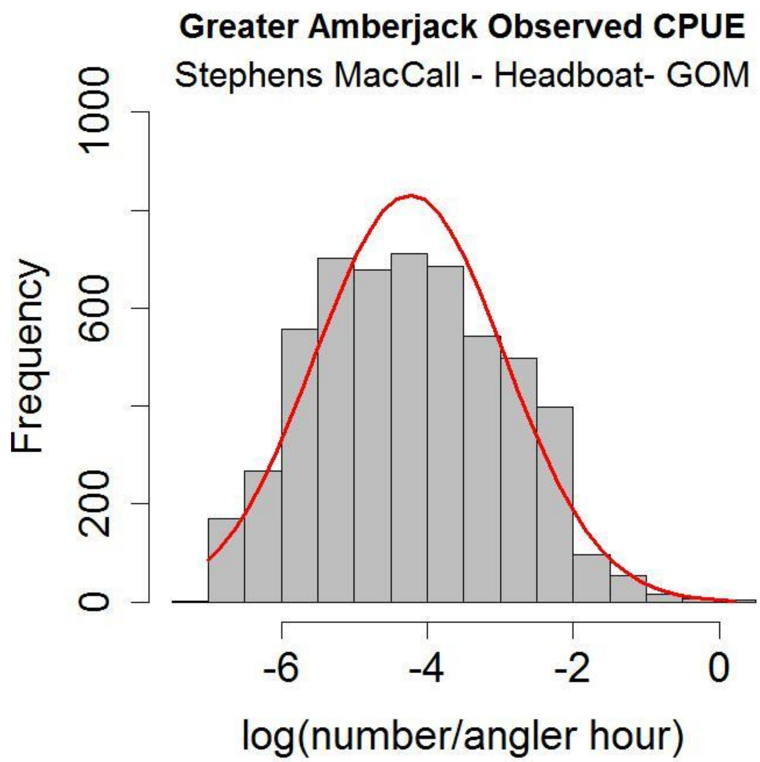

Figure 4. Frequency distribution of catch rates on positive trips. The red line is the expected normal distribution.

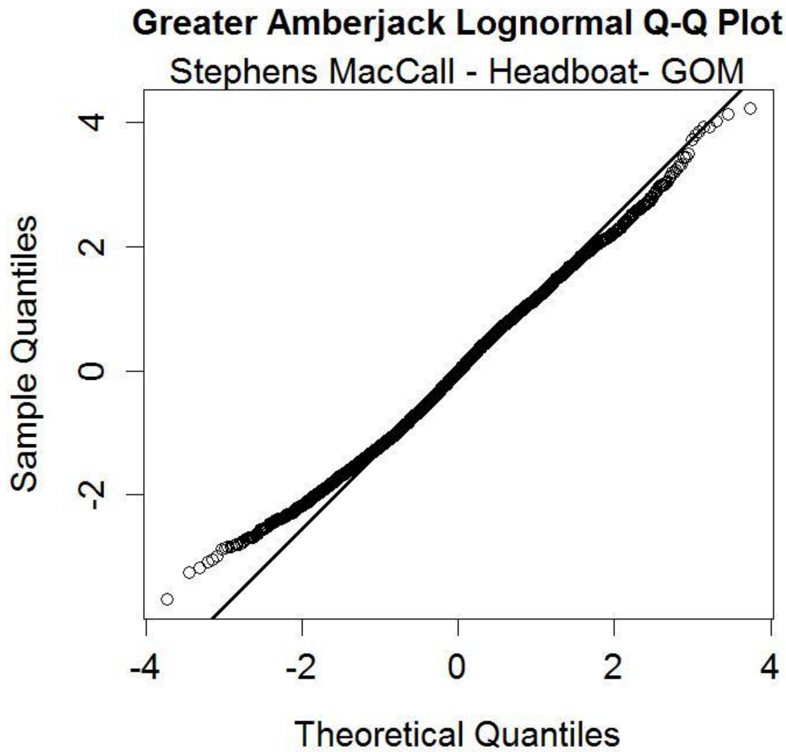

Figure 5. Q-Q plot of CPUE.

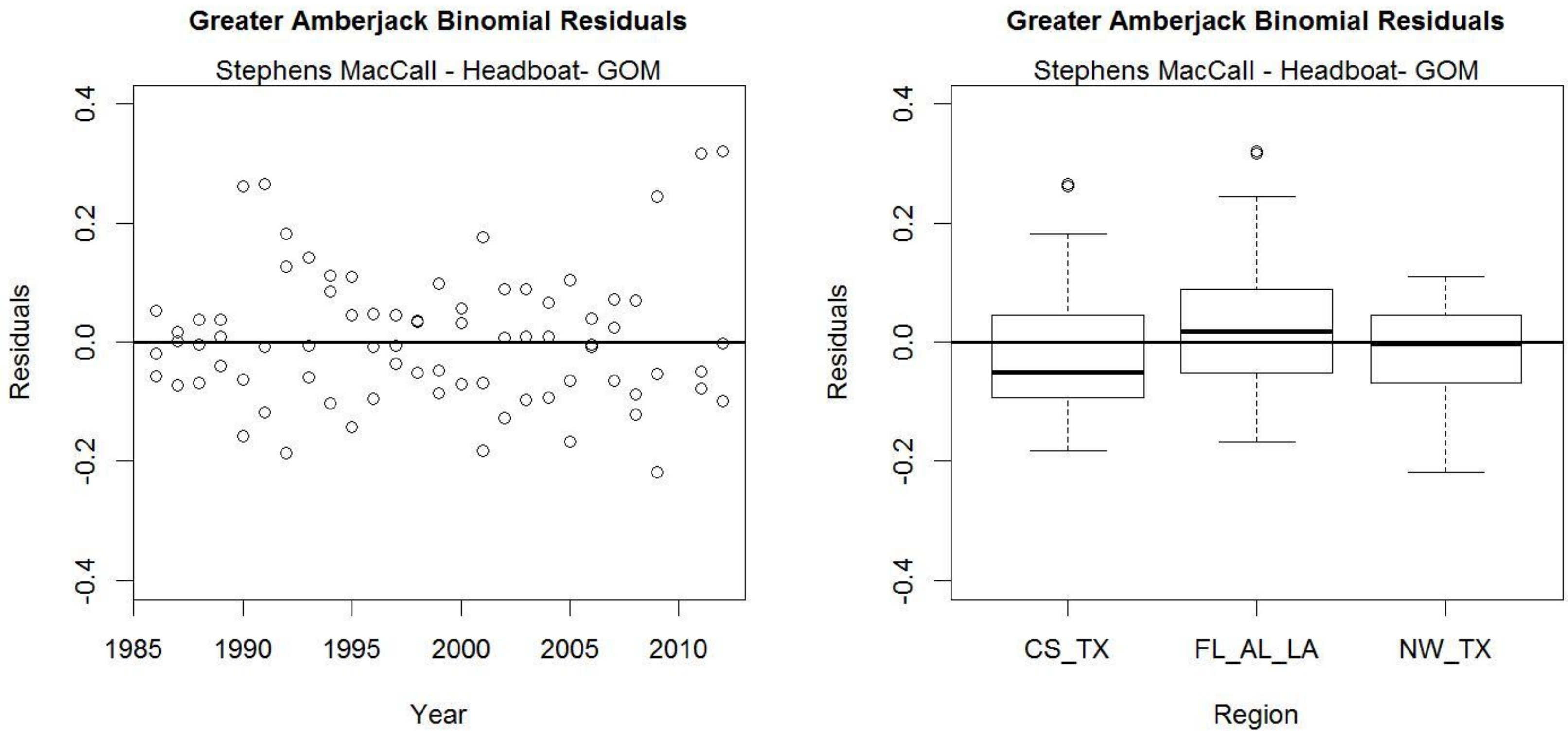

Figure 6. Residuals from the binomial model on proportion of positive trips, by year (left) and by region (right).

Appendix B: Number of total trip and trips that reported having caught greater amberjack across strata

Table 4. The total trips, number of positive trips, and percentage of positive trips by year for a full-day trips only dataset and for a Stephens and MacCall selected trips dataset, as well as the percentage of trips retained by the Stephens and MacCall trip selection procedure for the headboat fishery in the Gulf of Mexico.

Year	Total Trips	Positive Trips	Percent of Positive Trips	Selected Trips	Positive Selected Trips	Percent of Positive Selected Trips	Percent of Trips Selected
1986	2248	1012	45.02	509	367	72.10	22.64
1987	2666	961	36.05	523	299	57.17	19.62
1988	2829	821	29.02	518	317	61.20	18.31
1989	2468	863	34.97	427	258	60.42	17.30
1990	3178	418	13.15	496	182	36.69	15.61
1991	2882	444	15.41	558	209	37.46	19.36
1992	3265	764	23.40	661	320	48.41	20.25
1993	3398	699	20.57	758	302	39.84	22.31
1994	4011	659	16.43	804	256	31.84	20.04
1995	3071	640	20.84	707	267	37.77	23.02
1996	3229	579	17.93	691	277	40.09	21.40
1997	2036	333	16.36	474	180	37.97	23.28
1998	2535	347	13.69	597	167	27.97	23.55
1999	1752	218	12.44	374	127	33.96	21.35
2000	2438	363	14.89	469	142	30.28	19.24
2001	2104	410	19.49	466	208	44.64	22.15
2002	1765	461	26.12	417	194	46.52	23.63
2003	1548	470	30.36	373	202	54.16	24.10
2004	1803	441	24.46	371	206	55.53	20.58
2005	1943	310	15.95	454	167	36.78	23.37
2006	1790	324	18.10	416	156	37.50	23.24
2007	1709	296	17.32	495	156	31.52	28.96
2008	993	248	24.97	200	98	49.00	20.14
2009	1177	324	27.53	308	158	51.30	26.17
2010	865	169	19.54				
2011	507	160	31.56	169	88	52.07	33.33
2012	694	200	28.82	184	91	49.46	26.51

Table 5. Total trips, number of positive trips and percentage of positive trips by year and region for headboat fishing trips in the Gulf of Mexico selected by the Stephens and MacCall trip selection procedure. Some data excluded from table due to confidentiality.

	Selected Trips by Region			**Positive Selected Trips by Region**			**Percent of Positive Selected Trips by Region**		
Year	CW TX, SW TX	NW TX	FL, AL, LA	CW TX, SW TX	NW TX	FL, AL, LA	CW TX, SW TX	NW TX	FL, AL, LA
1986	56	293	160	42	207	118	75.00	70.65	73.75
1987	85	326	112	51	190	58	60.00	58.28	51.79
1988	82	265	171	53	161	103	64.63	60.75	60.23
1989	98	155	174	70	99	89	71.43	63.87	51.15
1990	148	167	181	107	48	27	72.30	28.74	14.92
1991	104	219	235	-	-	75	-	-	31.91
1992	89	285	287	70	87	163	78.65	30.53	56.79
1993	138	314	306	90	123	89	65.22	39.17	29.08
1994	137	284	383	74	115	67	54.01	40.49	17.49
1995	186	261	260	97	124	46	52.15	47.51	17.69
1996	117	293	281	49	115	113	41.88	39.25	40.21
1997	84	176	214	41	75	64	48.81	42.61	29.91
1998	84	264	249	35	84	48	41.67	31.82	19.28
1999	34	174	166	14	46	67	41.18	26.44	40.36
2000	69	237	163	32	79	31	46.38	33.33	19.02
2001	74	228	164	28	86	94	37.84	37.72	57.32
2002	151	212	54	63	110	21	41.72	51.89	38.89
2003	106	171	96	57	91	54	53.77	53.22	56.25
2004	128	163	80	70	97	39	54.69	59.51	48.75
2005	125	233	96	49	105	13	39.20	45.06	13.54
2006	139	227	50	62	77	17	44.60	33.92	34.00
2007	231	176	88	72	61	23	31.17	34.66	26.14
2008	41	39	120	-	-	62	-	-	51.67
2009	101	98	109	56	27	75	55.45	27.55	68.81
2010									
2011	112	32	25	58	12	18	51.79	37.50	72.00
2012	-	-	37	-	-	26	-	-	70.27

Table 6. Total trips, number of positive trips and percentage of positive trips by year and season for headboat fishing trips in the Gulf of Mexico selected by the Stephens and MacCall trip selection procedure. Some data excluded from table due to confidentiality.

Year	Selected Trips by Season				Positive Selected Trips by Season				Percent of Positive Selected Trips by Season			
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
1986	43	76	225	165	32	40	161	134	74.42	52.63	71.56	81.21
1987	50	108	227	138	24	50	136	89	48.00	46.30	59.91	64.49
1988	48	117	214	139	28	56	144	89	58.33	47.86	67.29	64.03
1989	33	82	167	145	17	37	104	100	51.52	45.12	62.28	68.97
1990	48	100	183	165	28	28	76	50	58.33	28.00	41.53	30.30
1991	68	92	223	175	37	29	93	50	54.41	31.52	41.70	28.57
1992	47	121	288	205	23	51	156	90	48.94	42.15	54.17	43.90
1993	46	171	279	262	18	67	128	89	39.13	39.18	45.88	33.97
1994	66	150	338	250	15	35	134	72	22.73	23.33	39.64	28.80
1995	63	142	273	229	22	54	120	71	34.92	38.03	43.96	31.00
1996	53	99	322	217	17	28	153	79	32.08	28.28	47.52	36.41
1997	23	101	246	104	7	33	105	35	30.43	32.67	42.68	33.65
1998	35	99	313	150	6	27	108	26	17.14	27.27	34.50	17.33
1999	11	100	192	71	3	21	78	25	27.27	21.00	40.63	35.21
2000	14	77	257	121	6	30	75	31	42.86	38.96	29.18	25.62
2001	6	49	262	149	4	19	138	47	66.67	38.78	52.67	31.54
2002	27	61	204	125	8	26	118	42	29.63	42.62	57.84	33.60
2003	12	63	196	102	-	-	120	51	-	-	61.22	50.00
2004	15	39	191	126	6	20	118	62	40.00	51.28	61.78	49.21
2005	5	54	280	115	3	15	101	48	60.00	27.78	36.07	41.74
2006	12	48	224	132	4	16	88	48	33.33	33.33	39.29	36.36
2007	8	62	291	134	5	24	94	33	62.50	38.71	32.30	24.63
2008	8	17	135	40	4	13	62	19	50.00	76.47	45.93	47.50
2009	-	-	204	74	-	-	105	36	-	-	51.47	48.65
2010												
2011	-	-	28	74	-	-	15	40	-	-	53.57	54.05
2012	33	41	38	72	15	12	20	44	45.45	29.27	52.63	61.11