Standardized catch rates for gag grouper from the Gulf of Mexico headboat fishery during 1986-2010

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SEDAR33-AW17

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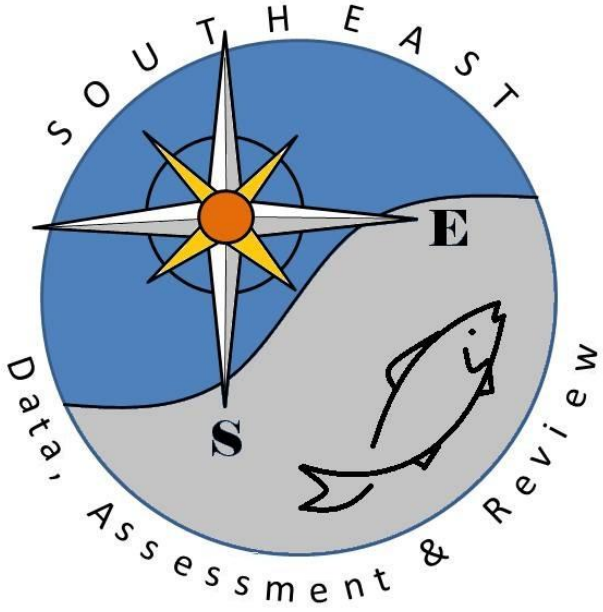

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Introduction

The recreational fishery in the Gulf of Mexico is surveyed by the Marine Recreational Fishery Statistics Survey (MRFSS), the Texas Marine Sport-Harvest Monitoring Program by the Texas Parks and Wildlife Department (TPWD), and the Headboat Survey (HBS) conducted by NMFS, Southeast Fisheries Science Center, Beaufort, NC. The three surveys provide information about catch in numbers, fishing effort, and length and weight samples. The MRFSS and the TPWD survey are sampling based programs, while the HBS is a census of headboats using logbooks provided to all headboats to report total landings and effort per trip. The purpose of this report is to outline the development of a standardized index of abundance for gag grouper using the HBS data.

Methods

Headboat survey data

The HBS collects catch and effort data for individual vessel 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. Catch rate was calculated as the number of gag grouper landed per angler hour. 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 angler hours per trip was calculated as the product of the number of fishers and the assumed hours fished.

Data exclusions and trip selection

The data were evaluated to determine the spatial distribution of headboat catch and effort. Approximately 93% of trips catching gag grouper, which represents 97% of the catch in pounds, were caught off Florida and Alabama; therefore, the index was developed for only this region.

The gag grouper recreational fishery has been managed using a few management strategies including size limits, bag limits, and fishing seasons. The data were explored to determine the number of trips that reached the cumulative bag limit. Less than one percent of all trips catching gag grouper reached the cumulative bag limit. Given that so few trips reached the cumulative bag limit, they were left in the database for analysis.

Fishing behavior was assumed to have been altered by the implementation of seasonal closures, so that fishers would avoid catching gag grouper. Seasonal closures were first implemented in 2005 and fell on the following dates:

2005-2008: January 1 – February 15, March 16 – December 31,

2009-2010: January 1- February 1, April 1 – December 31,

The dataset was restricted to those trips that fished during open fishing seasons. Table 1 summarizes the number of trips catching gag grouper and the total number of trips during the open and closed seasons. The majority of 2011 and the majority of 2012 were closed to fishing and were therefore excluded from the analysis. In 2011, the fishing season for gag was open from September 16 – November 14 and in 2012, the fishing season was open from June 14 until October 30.

Table 1. The number of trips catching gag grouper during the open and closed fishing seasons. Fishing seasons began in 2005 and varied in timing and duration between years.

Year	Fishing season	Number of trips catching gag grouper	Total number of trips
2005	Open	2333	6101
2006	Open	1238	5414
2007	Open	1253	5955
2008	Open	1939	6241
2009	Open	1924	7345
2010	Open	1790	5805
2005	Closed	218	422
2006	Closed	144	481
2007	Closed	42	446
2008	Closed	78	380
2009	Closed	23	1054
2010	Closed	45	877

The Stephens-McCall approach was used to identify trips that targeted gag grouper. 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 gag grouper habitat. If effort on a trip was determined to occur in similar habitat to gag grouper, then that trip was used in the analysis (Stephens and MacCall 2004).

Standardized index of abundance development

Delta lognormal approach

A delta-lognormal modeling approach was used to develop a standardized index for the headboat fishery during 1986-2010. The delta-lognormal modeling approach combines separate generalized linear model (GLM) analyses of the proportion of successful trips (trips that landed gag grouper) and 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). Parameterization of each model was accomplished using a stepwise approach and Akaike's information criteria (AIC). 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. The CPUE, catch per unit effort, was calculated on an individual trip basis and was equal to the number of fish caught on a given trip divided by the effort.

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 not examined because many of these interactions were confounded with one another (such as the interaction of year and month confounding with the regulatory season factor). The final delta-lognormal model was fit using a SAS macro, GLIMMIX (Russ Wolfinger, SAS Institute). To facilitate visual comparison, the standardized index and the nominal CPUE series were scaled by dividing each value in the time-series by the mean value of the entire time-series.

Table 2 summarizes the explanatory variables that were examined as possible influences on the proportion of positive interviews, and on the catch rates of trips reporting the capture of gag grouper. Tables summarizing the he total number of trips, the number of positive trips, and the proportion of trips catching gag grouper by factor can be found in Appendix A.

Table 2. Explanatory variables that were examined as part of the CPUE standardization process.

Factor	Levels	Description
Year	25	1986-2010
Season	4	Nov-Jan, Feb-Apr, May-July, Aug-Oct
Length_day	4	Half-day, Three-qtr day, Full-day, Multi-day
Ang_bins	7	Bins for the number of anglers: 10, 20, 30, 40, 50, 60, 70+

Results and discussion

The Stephens-MacCall approach was used to identify trips that targeted gag grouper. The left panel of Figure 1 shows the critical probability which minimizes the difference between the predicted number and the observed number of trips catching gag grouper. The right panel of Figure 1 shows the frequency of trips associated with the critical probability. Given these diagnostics, a fair number of trips are retained in the database to develop an index of abundance. Figure 2 shows the percent of trips retained by the Stephen-MacCall approach that reported the capture of co-occurring species and gag grouper.

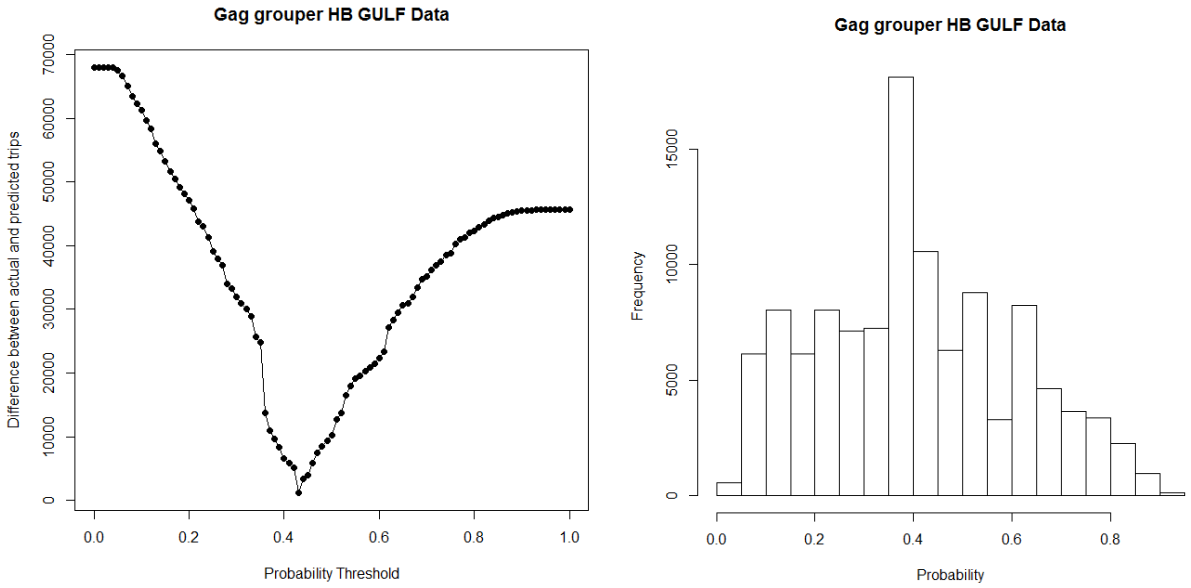

Figure 1. The left panel shows difference between the number of records in which gag grouper were observed and the number in which they were predicted. A critical value of 0.42 minimizes the difference. The right panel shows a histogram of the frequency of probabilities generated by the species regression.

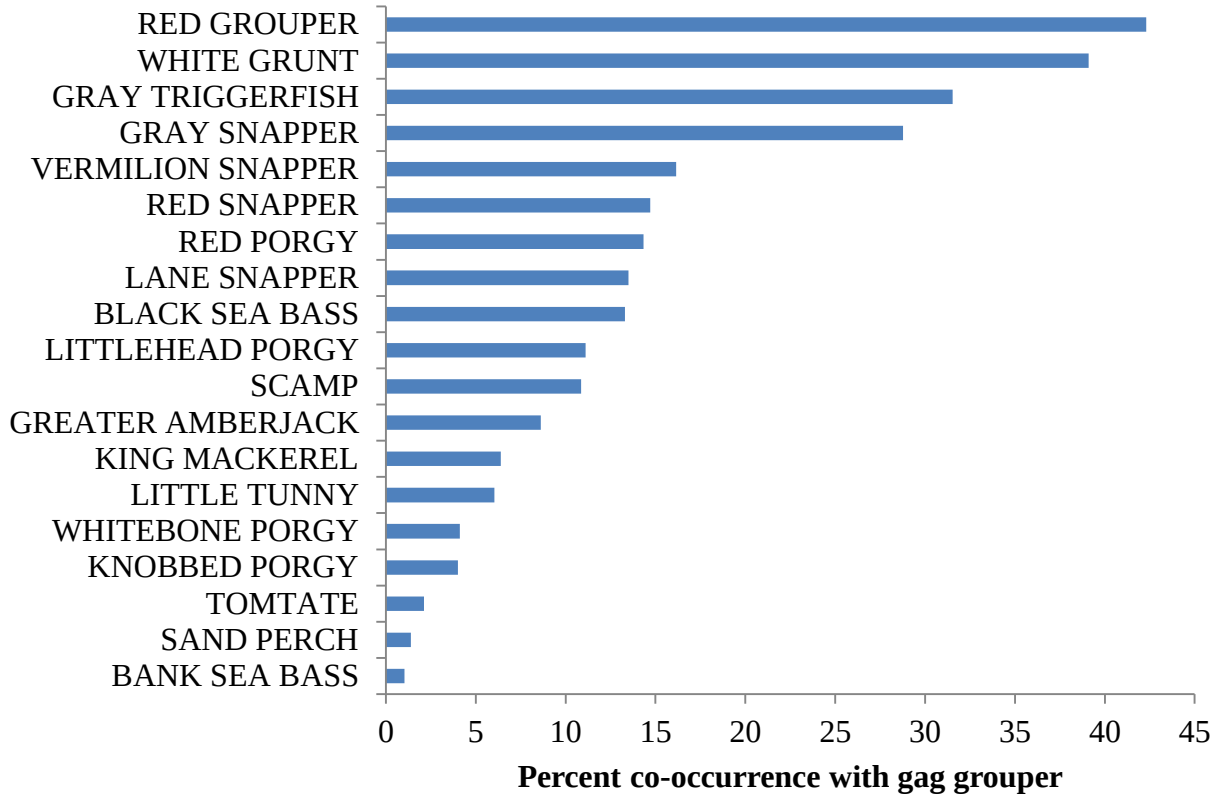

Figure 2. The percentage of trips retained through Stephens-MacCall and reporting the co-occurring species and gag grouper.

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 *PPT* is a binomial indicating the proportion of trips capturing gag grouper, α represents the parameter estimate of each factor, μ represents the mean, and ε represents the error term.

$$\text{Ln CPUE} = \mu + \alpha 1\text{Year} + \alpha 2\ \text{Season} + \varepsilon$$

$$\text{PPT} = \mu + \alpha 1\text{Length\_day} + \alpha 2\ \text{Season} + \alpha 3\ \text{Year} + \varepsilon$$

Table 3 shows the final deviance tables for the lognormal and binomial models. One criterion for including a factor in the lognormal and binomial models is a reduction of 1% in the deviance. For the lognormal model, none of the factors considered resulted in a 1% reduction in the deviance. The top two factors, year and season, were included in the lognormal model because of this even though they did not meet the criteria. One-way interactions were initially investigated, but none were found to be significant and were not included in the models.

Table 3. Final deviance table for the regression of the Gulf of Mexico headboat fishery data subset by the Stephens-McCall approach. The table shows the sequential addition of explanatory variables to the model. The last line of the table section shows the final model.

Lognormal model							
Model	Factor	Factor DF	Residual DF	Residual deviance	% Dev reduction	AIC	log Like
Null	intercept	1	44575	207989.9	-	195163.4	-97580.7
Null + year	year	24	44551	205846.7	0.98	194749.6	-97349.8
Null+year+season	season	3	44572	207145.1	0.4	195036	-97490
Binomial model							
Model	Factor	Factor DF	Residual DF	Residual deviance	% Dev reduction	AIC	log Like
Null	intercept	1	44575	59563.8	-	59565.8	-29781.9
Null+length_day	length_day	3	44572	55063.3	7.55	55071.4	-27531.7
Null+length_day+season	season	3	44569	54066.4	1.8	54080.4	-27033.2
Null+length_day+season+year	year	25	44545	53282.8	1.4	53346.8	-26641.4

Table 4 and Figure 2 show the resulting standardized index of abundance for gag grouper from 1986-2010, as well as the nominal index, and measures of uncertainty. The standardized index follows the nominal throughout the time series. The diagnostic plots for the lognormal and binomial models are shown in Figures 3-5. The diagnostics indicate that the fit of these data to the lognormal and binomial models were acceptable. The index developed for SEDAR 33 was compared to those developed for previous assessments. The indices are not identical; however, they follow the same trends over time (Figure 6).

Table 4. Index values, upper confidence limits, lower confidence limits, and coefficient of variation for the headboat index for Gulf of Mexico gag grouper. CPUE values were scaled by the mean of the index.

Year	Standardized Index	CV	Lower 95% CI	Upper 95% CI	Nominal Index
1986	1.399	0.082	1.187	1.649	1.605
1987	1.556	0.083	1.318	1.837	1.673
1988	1.124	0.090	0.939	1.345	1.149
1989	1.065	0.102	0.869	1.307	1.023
1990	0.979	0.089	0.819	1.169	0.972
1991	0.709	0.105	0.575	0.875	0.801
1992	0.849	0.115	0.675	1.068	0.919
1993	0.866	0.101	0.708	1.058	0.930
1994	0.907	0.115	0.721	1.140	0.947
1995	0.768	0.120	0.604	0.975	0.669
1996	1.021	0.095	0.846	1.233	0.967
1997	0.996	0.099	0.818	1.213	0.740
1998	1.165	0.088	0.978	1.388	1.141
1999	1.276	0.087	1.072	1.518	1.357
2000	1.205	0.097	0.993	1.464	1.268
2001	0.612	0.135	0.468	0.801	0.595
2002	0.722	0.124	0.564	0.924	0.771
2003	1.002	0.102	0.818	1.228	0.991
2004	1.099	0.102	0.897	1.347	1.095
2005	1.152	0.076	0.990	1.342	1.138
2006	0.538	0.134	0.412	0.702	0.479
2007	0.646	0.134	0.495	0.844	0.632
2008	0.995	0.099	0.817	1.212	0.979
2009	0.931	0.104	0.757	1.145	0.875
2010	1.419	0.089	1.189	1.693	1.282

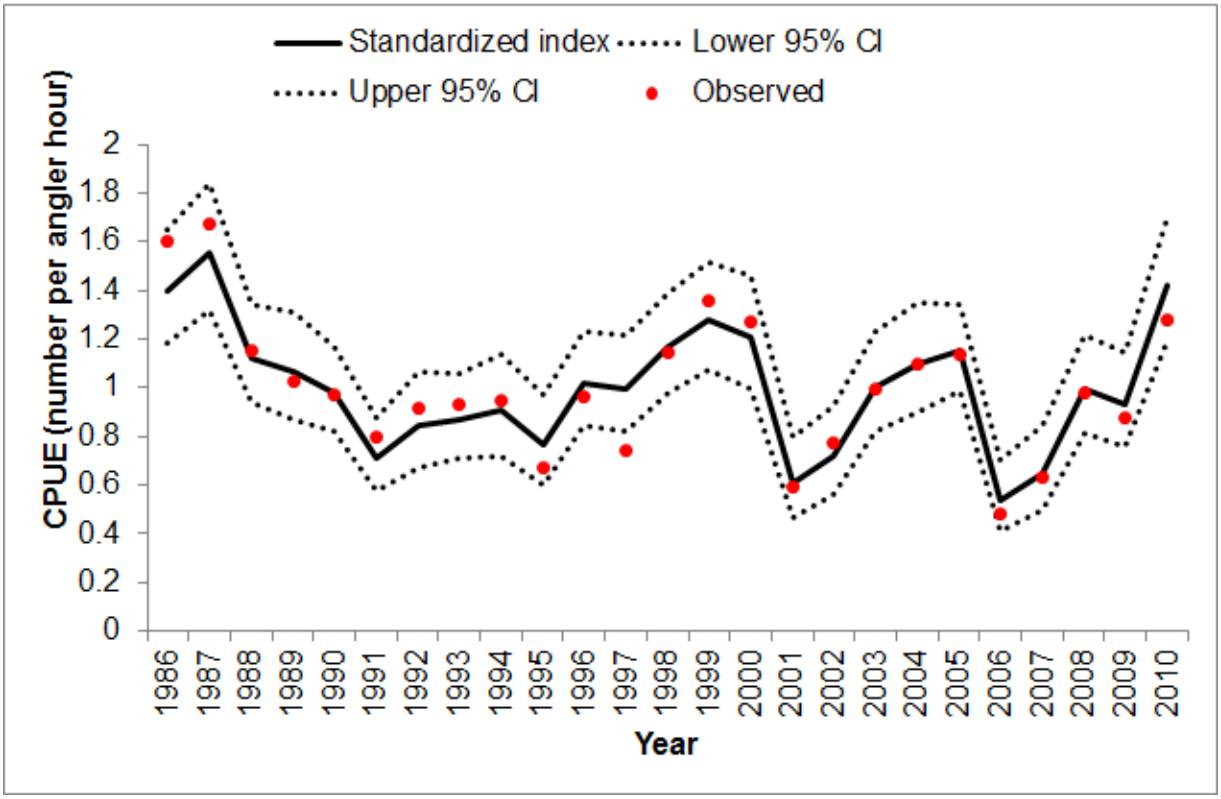

Figure 2. Nominal (observed) and standardized CPUE and the 95% confidence intervals for Gulf of Mexico gag grouper from the headboat fishery. CPUE values were scaled by the mean standardized index.

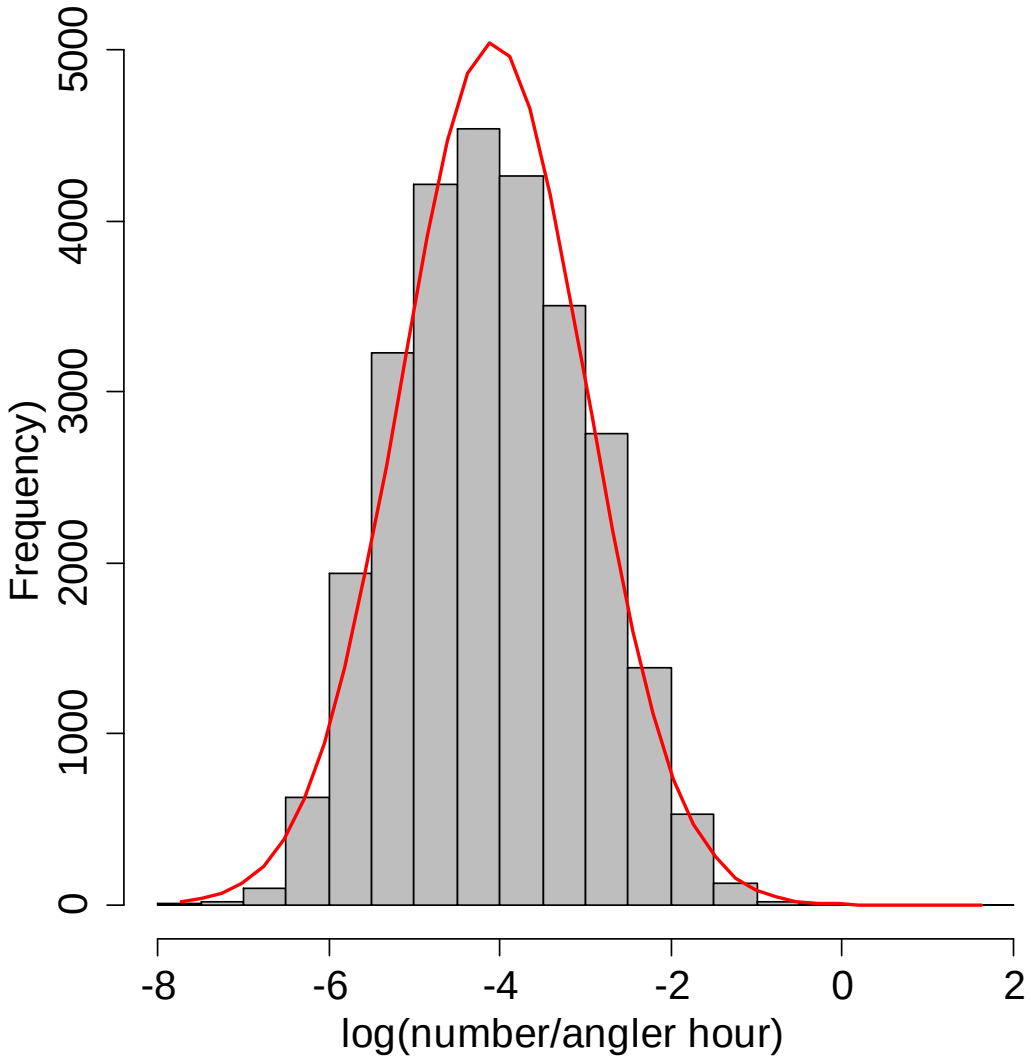

Figure 3. Frequency distribution of catch rates on positive interviews. The red line is the expected normal distribution.

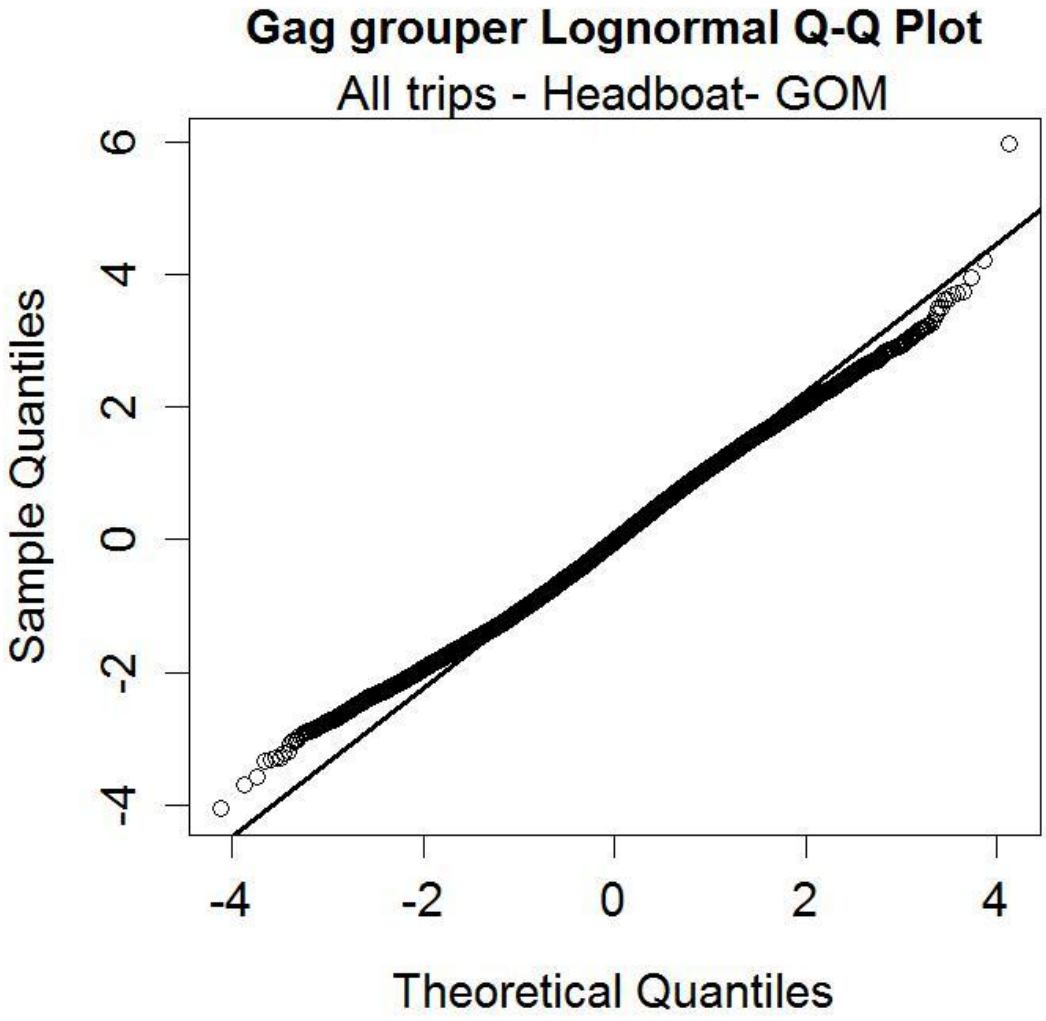

Figure 4. Q-Q plot of CPUE.

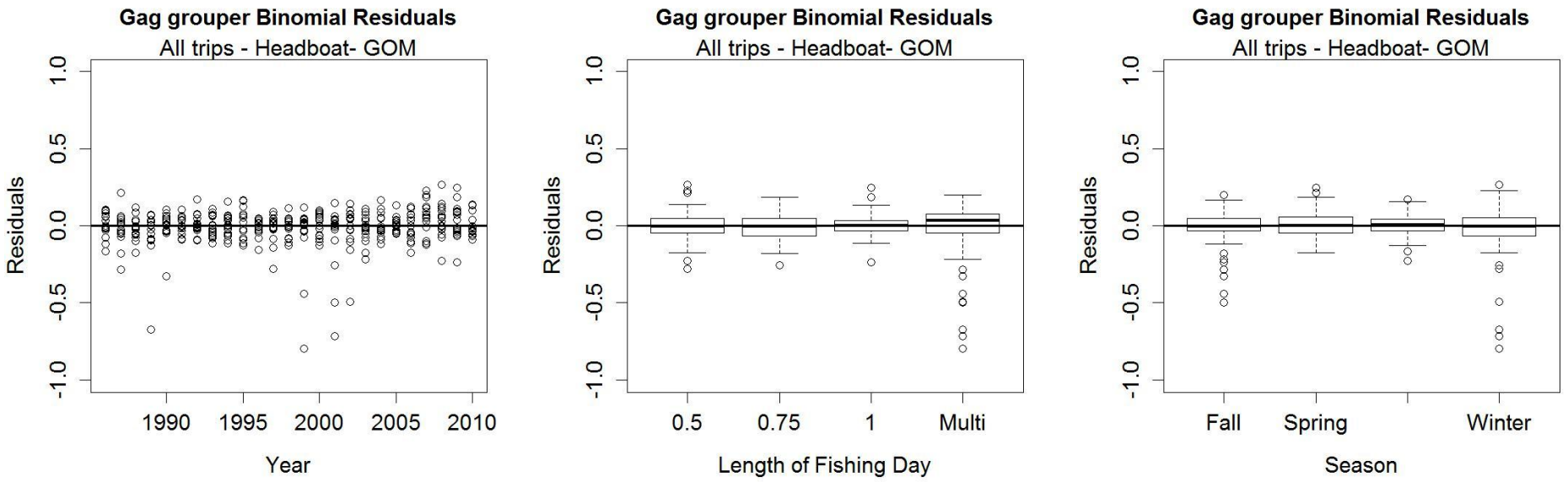

Figure 5. Residuals from the binomial model on proportion positive interviews, by factor.

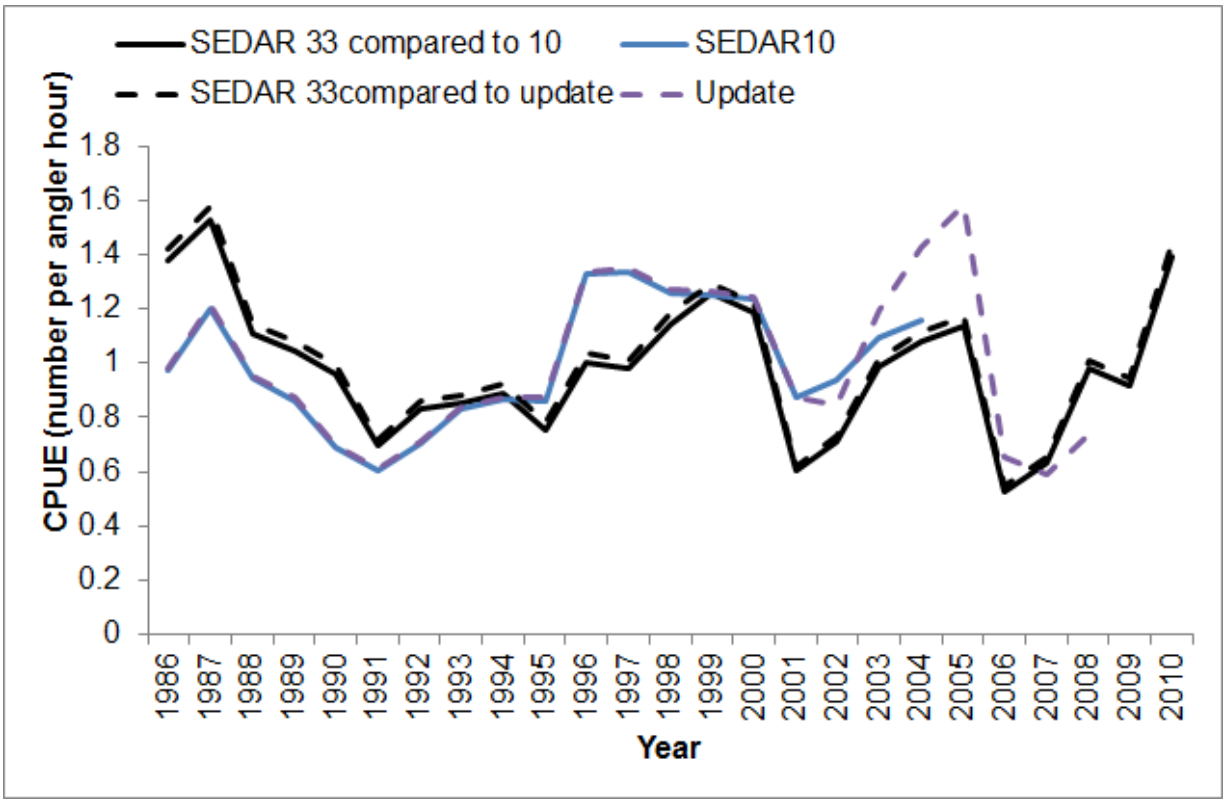

Figure 6. Comparison of the standardized indices from SEDAR 33 and SEDAR 10, which was also used for the update assessment of gag grouper. All indices were scaled by the mean of the overlapping period.

Appendix A.

Table A.1. The number of trips, the number of positive trips and the proportion of positive trips by year.

Year	Trips	Positive trips	Proportion positives
1986	1244	927	74.52
1987	1336	1015	75.97
1988	1622	1099	67.76
1989	1977	1160	58.67
1990	2862	1764	61.64
1991	2494	1400	56.13
1992	2527	1338	52.95
1993	2427	1420	58.51
1994	2254	1282	56.88
1995	1909	936	49.03
1996	1634	1019	62.36
1997	1503	904	60.15
1998	1819	1192	65.53
1999	1363	978	71.75
2000	1485	1045	70.37
2001	1202	714	59.40
2002	1302	760	58.37
2003	1583	1020	64.43
2004	2067	1256	60.76
2005	2019	1429	70.78
2006	1176	637	54.17
2007	1273	636	49.96
2008	1847	1109	60.04
2009	2045	1191	58.24
2010	1606	1023	63.70

Table A.2. The number of trips by year and length of day.

Year	Half-day	Three-quarter-day	Full-day	Multi-day
1986	236	139	841	28
1987	279	79	954	24
1988	449	185	891	97
1989	639	491	819	28
1990	761	850	1158	93
1991	513	883	993	105
1992	518	872	1076	61
1993	522	740	987	178
1994	464	490	1202	98
1995	706	481	689	33
1996	460	364	765	45
1997	520	251	675	57
1998	480	474	805	60
1999	393	259	638	73
2000	253	253	893	86
2001	134	377	585	106
2002	156	653	395	98
2003	135	935	430	83
2004	310	1238	440	79
2005	274	1011	668	66
2006	129	715	285	47
2007	271	622	331	49
2008	311	1037	404	95
2009	380	1294	284	87
2010	404	962	171	69
Total	9697	15655	17379	1845

Table A.3. The number of trips positive by year and length of day.

Year	Half-day	Three-quarter-day	Full-day	Multi-day
1986	166	96	638	27
1987	182	52	761	20
1988	207	96	706	90
1989	352	233	555	20
1990	360	550	774	80
1991	191	478	639	92
1992	121	515	645	57
1993	124	470	662	164
1994	96	208	886	92
1995	179	250	476	31
1996	155	243	580	41
1997	153	140	557	54
1998	151	318	669	54
1999	173	183	571	51
2000	73	129	768	75
2001	33	160	456	65
2002	34	370	277	79
2003	35	570	348	67
2004	84	781	331	60
2005	98	708	560	63
2006	18	383	192	44
2007	72	330	194	40
2008	109	637	276	87
2009	91	832	187	81
2010	158	673	126	66
Total	3415	9405	12834	1600

Table A.4 The proportion of positive trips by year and length of day.

Year	Half-day	Three-quarter-day	Full-day	Multi-day
1986	0.70	0.69	0.76	0.96
1987	0.65	0.66	0.80	0.83
1988	0.46	0.52	0.79	0.93
1989	0.55	0.47	0.68	0.71
1990	0.47	0.65	0.67	0.86
1991	0.37	0.54	0.64	0.88
1992	0.23	0.59	0.60	0.93
1993	0.24	0.64	0.67	0.92
1994	0.21	0.42	0.74	0.94
1995	0.25	0.52	0.69	0.94
1996	0.34	0.67	0.76	0.91
1997	0.29	0.56	0.83	0.95
1998	0.31	0.67	0.83	0.90
1999	0.44	0.71	0.89	0.70
2000	0.29	0.51	0.86	0.87
2001	0.25	0.42	0.78	0.61
2002	0.22	0.57	0.70	0.81
2003	0.26	0.61	0.81	0.81
2004	0.27	0.63	0.75	0.76
2005	0.36	0.70	0.84	0.95
2006	0.14	0.54	0.67	0.94
2007	0.27	0.53	0.59	0.82
2008	0.35	0.61	0.68	0.92
2009	0.24	0.64	0.66	0.93
2010	0.39	0.70	0.74	0.96
Overall	0.35	0.60	0.74	0.87

A.5. The number of trips by year and season. The season definitions are as follows: Spring: February-April , Summer: May-July , Fall: August-October, Winter – November-January.

Year	Fall	Spring	Summer	Winter
1986	310	275	328	331
1987	257	385	433	261
1988	367	373	586	296
1989	544	469	582	382
1990	767	680	703	712
1991	583	607	712	592
1992	669	557	739	562
1993	684	484	758	501
1994	588	548	754	364
1995	354	619	603	333
1996	513	259	601	261
1997	313	448	605	137
1998	448	397	659	315
1999	124	528	441	270
2000	334	398	573	180
2001	278	303	501	120
2002	321	325	463	193
2003	462	288	616	217
2004	356	600	899	212
2005	434	390	945	250
2006	308	185	506	177
2007	246	242	591	194
2008	360	302	860	325
2009	543	194	905	403
2010	481	161	624	340
Total	10644	10017	15987	7928

Table A.6. The number of positive trips by year and season. The season definitions are as follows: Spring: February-April , Summer: May-July , Fall: August-October, Winter – November-January.

Year	Fall	Spring	Summer	Winter
1986	222	210	221	274
1987	177	308	320	210
1988	211	268	382	238
1989	269	299	329	263
1990	400	452	375	537
1991	274	396	321	409
1992	316	299	349	374
1993	330	304	460	326
1994	309	322	419	232
1995	189	290	272	185
1996	297	167	377	178
1997	184	260	389	71
1998	287	224	437	244
1999	72	381	300	225
2000	228	293	365	159
2001	154	198	302	60
2002	197	197	224	142
2003	278	189	390	163
2004	241	387	484	144
2005	315	282	630	202
2006	133	100	270	134
2007	134	139	210	153
2008	205	209	411	284
2009	268	153	440	330
2010	269	110	392	252
Total	5959	6437	9069	5789

Table A.7. The proportion of positive trips by year and season. The season definitions are as follows: Spring: February-April , Summer: May-July , Fall: August-October, Winter – November-January.

Year	Fall	Spring	Summer	Winter
1986	0.72	0.76	0.67	0.83
1987	0.69	0.80	0.74	0.80
1988	0.57	0.72	0.65	0.80
1989	0.49	0.64	0.57	0.69
1990	0.52	0.66	0.53	0.75
1991	0.47	0.65	0.45	0.69
1992	0.47	0.54	0.47	0.67
1993	0.48	0.63	0.61	0.65
1994	0.53	0.59	0.56	0.64
1995	0.53	0.47	0.45	0.56
1996	0.58	0.64	0.63	0.68
1997	0.59	0.58	0.64	0.52
1998	0.64	0.56	0.66	0.77
1999	0.58	0.72	0.68	0.83
2000	0.68	0.74	0.64	0.88
2001	0.55	0.65	0.60	0.50
2002	0.61	0.61	0.48	0.74
2003	0.60	0.66	0.63	0.75
2004	0.68	0.64	0.54	0.68
2005	0.73	0.72	0.67	0.81
2006	0.43	0.54	0.53	0.76
2007	0.54	0.57	0.36	0.79
2008	0.57	0.69	0.48	0.87
2009	0.49	0.79	0.49	0.82
2010	0.56	0.68	0.63	0.74
Overall	0.56	0.64	0.57	0.73