United States Commercial Longline Vessel Standardized Catch Rates of Yellowedge Grouper in the Gulf of Mexico, 1991-2009

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Introduction

The National Marine Fisheries Service (NMFS) has been monitoring commercial landings and fishing effort of federally managed coastal finfishes in the Gulf of Mexico and U.S. South Atlantic through the Southeast Fisheries Science Center's Coastal Fisheries Logbook Program (CFLP). The CFLP collects landings and effort data by fishing trip which is submitted by fishers who own or operate a federally permitted commercial fishing vessel. Most data collected by the CFLP are for fisheries managed by the Gulf of Mexico and South Atlantic Fishery Management Councils. The CFLP began in 1990 to obtain a complete census of the coastal fisheries, with the exception of Florida, where only 20 percent of vessels were selected to report. Beginning in 1993, 100 percent of federally permitted Florida vessels were required to report.

Using the CFLP's available catch per unit effort (CPUE) data, an index of abundance was created for yellowedge grouper in the Gulf of Mexico. Vertical gear landings accounted for only 6 percent of the landings, while longline accounted for about 94 percent of yellowedge grouper landings. As vertical landings of yellowedge grouper appeared to incidental an index was only created for longline effort. The index was developed from bottom longline landings and effort data reported for trips made in the Gulf of Mexico from 1991-2009. While there were a relatively low number of trips reported 1990-1992, when compared to other years in the time series, only 1991 and 1992 had sufficient data to include in the analyses. The lower number of trips for these 3 years is likely due to the 20 percent vessel selection in Florida.

Methods

Available Data

For each fishing trip, the CFLP database included a unique trip identifier, the landing date, fishing gear deployed, areas fished (Figure 1), number of days at sea, number of crew, gear specific fishing effort, species caught and weight of the landings. Fishing effort data available for longline included number of sets and number of hooks fished per set. Multiple areas fished and multiple gears fished may be recorded for a single fishing trip. In such cases, assigning catch and effort to specific locations or gears was not always possible; therefore, only trips which reported one area category (see area factor below) and one gear fished were included in these analyses.

Data were further restricted to include only those trips with landings and effort data received by the CFLP within 45 days of the completion of the trip. Approximately 67 percent of longline trips were retained for analyses. Reporting delays beyond 45 days likely results in less accurate effort data. Landings data may still be reliable even with lengthy reporting delays if dealer trip ticket reports were referenced by the reporting fisher.

Clear outliers in the data, i.e. effort values falling outside the 99.5 percentile of the data, were also excluded from the analyses. These included trips in which the number of hooks per set reported was less than 18 or greater than 3,000. Longline trips that reported days at sea greater than 20, number of crew greater than 6, more than 24 sets per day, or longline lengths not between 1 and 20 miles were also excluded. Data that meet these criteria were considered erroneous due to reporting or data entry error.

Season was also taken into account when determining the availability of data. Deep-water grouper season had remained open year-round from 1991 through 2003. Beginning in 2004 however, deep-water grouper quota restrictions have resulted in annual closures through 2009. All trips made during closed season were excluded from the analyses.

Yellowedge grouper trips were identified using a data subsetting technique (modified from Stephens and MacCall, 2004) intended to restrict the data set to trips with fishing effort in yellowedge grouper habitat. Such an approach was necessary because fishing location was not reported to the CFLP at a spatial scale adequate to identify targeting based upon the habitat where the fishing occurred. The modified Stephens and MacCall method was an objective approach in which a logistic regression was applied to estimate the probability that yellowedge grouper could have been encountered given the presence or absence of other species reported from the trip. As a function of the species reported from a trip, a score was assigned to the trip and that score was converted into the probability of observing yellowedge grouper. Trips with scores above a critical value were included in the CPUE analysis. That critical value was set at the score that minimized the number of predictions of yellowedge grouper occurring when the species was actually absent (false positives) while also minimizing incorrect predictions of yellowedge grouper absence when the species was actually present (false negatives).

Targeted trips were identified independently for the eastern Gulf of Mexico (statistical areas 2-7) and the western Gulf (statistical areas 8-21). This east-west partitioning approximately matched the demarcation line at Cape San Blas where longline gear is restricted to 20 fathoms or greater depths (east) and 50 fathoms or greater depths (west). Prior to identifying targeted trips, data from areas 1 and 12 were excluded from the analyses due to small sample sizes. For each region, eastern and western Gulf of Mexico, those species that were reported from one percent or more of all longline trips were included in the data subsetting analyses. Figure 2A and 2B provide species-specific regression coefficients. The magnitude of the coefficients indicates the predictive impact of each species.

Index Development

Longline catch rate was calculated in gutted pounds per hook. For each trip, catch per unit effort was calculated as:

CPUE = gutted pounds of yellowedge grouper/(number of sets *number of hooks per set)

Eight factors were considered as possible influences on longline proportion of trips that landed yellowedge grouper and the catch rate of yellowedge grouper. In order to develop a well balanced sample design, the factors were defined as:

Yellowedge grouper longline

Factor	Levels	Value
Year	19	1991-2009
Area(*area_cat3*)*	10	Stat areas 2-3, 4, 5, 6-7, 8, 9, 10-11, 13-15, 16-18, 19-21 (see Fig 1.)
Days at Sea (*away_cat*)*	3	1-7, 8-11, 12+ days
Distance between Hooks (*hook_cat*)*	2	1-25, 26+ feet
Number of Crew	3	1-2, 3, 4-6 crew members
Season	4	Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec
Total hooks fished[1]	3	<12,000; 12,000-28,999; 29,000+ hooks
Longline length	2	<5, 5+ miles

*Names in parentheses appear in some figures and tables.
[1]Total hooks fished was only tested in the proportion positive analysis.
The delta lognormal model approach (Lo et al. 1992) was used to construct standardized indices of abundance. This method combines separate general linear model (GLM) analyses of the proportion of successful trips (trips that landed yellowedge grouper) and the catch rates on successful trips to construct a single standardized CPUE index. Parameterization of each model was accomplished using a GLM procedure (GENMOD; Version 8.02 of the SAS System for Windows © 2000. SAS Institute Inc., Cary, NC, USA).

For each GLM analysis of proportion positive trips, a type-3 model was fit, a binomial error distribution was assumed, and the logit link was selected. The response variable was proportion successful trips. During the analysis of catch rates on successful trips, a type-3 model assuming lognormal error distribution was examined. The linking function selected was "normal", and the response variable was log(CPUE). The response variable of longline data was calculated as: log(CPUE) = ln(pounds of yellowedge grouper/hook). All 2-way interactions among significant main effects were examined. Higher order interaction terms were not examined.

A forward stepwise regression procedure was used to determine the set of fixed factors and interaction terms that explained a significant portion of the observed variability. Each potential factor was added to the null model sequentially and the resulting reduction in deviance per degree of freedom was examined. The factor that caused the greatest reduction in deviance per degree of freedom was added to the base model if the factor was significant based upon a Chi-Square test ($p<0.05$), and the reduction in deviance per degree of freedom was $\geq 1\%$. This model then became the base model, and the process was repeated, adding factors and interactions individually until no factor or interaction met the criteria for incorporation into the final model.

Once a set of fixed factors was identified, the influence of the YEAR*FACTOR interactions were examined. YEAR*FACTOR interaction terms were included in the model as random effects. Selection of the final mixed model was based on the Akaike's Information Criterion (AIC), Schwarz's Bayesian Criterion (BIC), and a chi-square test of the difference between the –2 log likelihood statistics between successive model formulations (Littell et al. 1996).

The final delta-lognormal model was fit using a SAS macro, GLIMMIX (Russ Wolfinger, SAS Institute). All factors were modeled as fixed effects except two-way interaction terms containing YEAR which were modeled as random effects. To facilitate visual comparison, a relative index and relative nominal CPUE series were calculated by dividing each value in the series by the mean value of the series.

Results and Discussion

The final models for the binomial on proportion positive trips (PPT) and the lognormal on CPUE of successful trips were:

Yellowedge grouper longline 1991-2009:

PPT = Area + Days at Sea + Year

LOG(CPUE) = Area + Distance between Hooks + Year + Year*Area

The linear regression statistics and analysis of the mixed model formulations of the final models are summarized in Table 1.

Relative nominal CPUE, number of trips, proportion positive trips, and relative abundance indice are provided in Table 2 for the vertical line model. The delta-lognormal abundance index developed, with 95% confidence intervals, is shown in Figure 3.

Plots of the proportion of positive trips per year, nominal cpue, frequency distributions of the proportion of positive trips, frequency distributions of log(CPUE) for positive catch, cumulative normalized residuals, and plots of chi-square residuals by each main effect for the binomial and lognormal models are shown in Figures 4-7. Those diagnostic plots indicate that the fit of the data to the lognormal and binomial models was acceptable. There were some outliers among these data, however, and the frequency distribution of log(CPUE) from these data were somewhat skewed from the expected normal distribution. Those variations from the expected fit of the data were not sufficient to violate assumptions of the analyses. The observed positive yellowedge grouper trips ranged from approximately 83 to 97% and were at the edge of the range required for the analysis.

Yellowedge grouper standardized catch rates for longline vessels remained relatively constant from 1993 through 2002, but rose steadily from 2003 through 2008, and dropped-off in 2009. Rates in 1991 and 1992 were notably higher, however this may be attributed to a lower number of trips and a few trips with high catch rates. Coefficients of variation ranged from 0.15-0.23, with a higher CV from 1991-1993, but were generally consistent over the rest of the time series. Those higher initial CVs may have been due to smaller sample sizes (i.e. sampling error) during the period of 20 percent reporting in Florida.

Acknowledgements

Thanks to Drs. John Walter and John Quinlan for the valuable discussions, advice, and help regarding methods for identifying yellowedge grouper trips.

Literature Cited

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Lo, N.C., L.D. Jackson, 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.

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

Table 1. Linear regression statistics for the GLM models on proportion positive trips (**A**) and catch rates on positive trips (**B**) of yellowedge grouper in the Gulf of Mexico for vessels reporting longline gear landings 1991-2009. Analysis of the mixed model formulations of the positive trip model (**C**). The likelihood ratio was used to test the difference of –2 REM log likelihood between two nested models. The final model is indicated with gray shading. See text for factor (effect) definitions.

A.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
YEAR	18	500	55.92	3.11	<.0001	<.0001
AREA_CAT3	9	500	150.59	16.73	<.0001	<.0001
AWAY_CAT	2	500	39.75	19.88	<.0001	<.0001

B.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
YEAR	18	161	60.52	3.36	<.0001	<.0001
AREA_CAT3	9	161	170.42	18.94	<.0001	<.0001
HOOK_CAT	1	4503	95.79	95.79	<.0001	<.0001

C.

Catch Rates on Positive Trips	*-2 REM Log likelihood*	*Akaike's Information Criterion*	*Schwartz's Bayesian Criterion*	*Likelihood Ratio Test*	*P*
Year + Area + Hook_dist	15325.4	15325.4	15331.8	-	-
*Year + Area + Hook_dist + Year*Area*	15264.4	15268.4	15274.9	61.0	<0.0001

Table 2. Longline relative nominal CPUE, number of trips, proportion positive trips, and relative abundance index for yellowedge grouper (1991-2009) in the Gulf of Mexico.

YEAR	Relative Nominal CPUE	Trips	Proportion Successful Trips	Relative Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1991	2.121273	103	0.902913	1.490088	0.948035	2.342067	0.229020
1992	1.699324	104	0.942308	1.535237	1.002014	2.352214	0.215787
1993	0.802270	160	0.85	0.592673	0.371912	0.944477	0.236192
1994	0.854021	293	0.849829	0.874584	0.612426	1.248962	0.179583
1995	1.331839	294	0.840136	0.832388	0.577256	1.200283	0.184550
1996	0.720055	179	0.865922	0.713038	0.473558	1.073626	0.206792
1997	0.751086	339	0.887906	0.875103	0.630739	1.214139	0.164828
1998	0.620016	314	0.837580	0.724983	0.504247	1.042347	0.183047
1999	0.911881	375	0.853333	0.830364	0.586898	1.174829	0.174821
2000	0.885752	408	0.892157	0.846481	0.610817	1.173068	0.164237
2001	0.822566	390	0.902564	0.812218	0.586572	1.124666	0.163820
2002	0.770312	334	0.862275	0.787201	0.555335	1.115878	0.175792
2003	0.732168	430	0.918605	0.901225	0.658892	1.232684	0.157562
2004	0.743367	304	0.911184	0.862774	0.616870	1.206703	0.168934
2005	0.885451	272	0.889706	1.143101	0.816343	1.600651	0.169532
2006	0.900441	266	0.921053	1.209399	0.877828	1.666211	0.161248
2007	1.110161	257	0.972763	1.267596	0.932349	1.723388	0.154495
2008	1.305943	228	0.929825	1.496154	1.083536	2.065901	0.162390
2009	1.032077	221	0.932127	1.205392	0.861889	1.685798	0.168903

Figure 1. Coastal Logbook defined fishing areas.

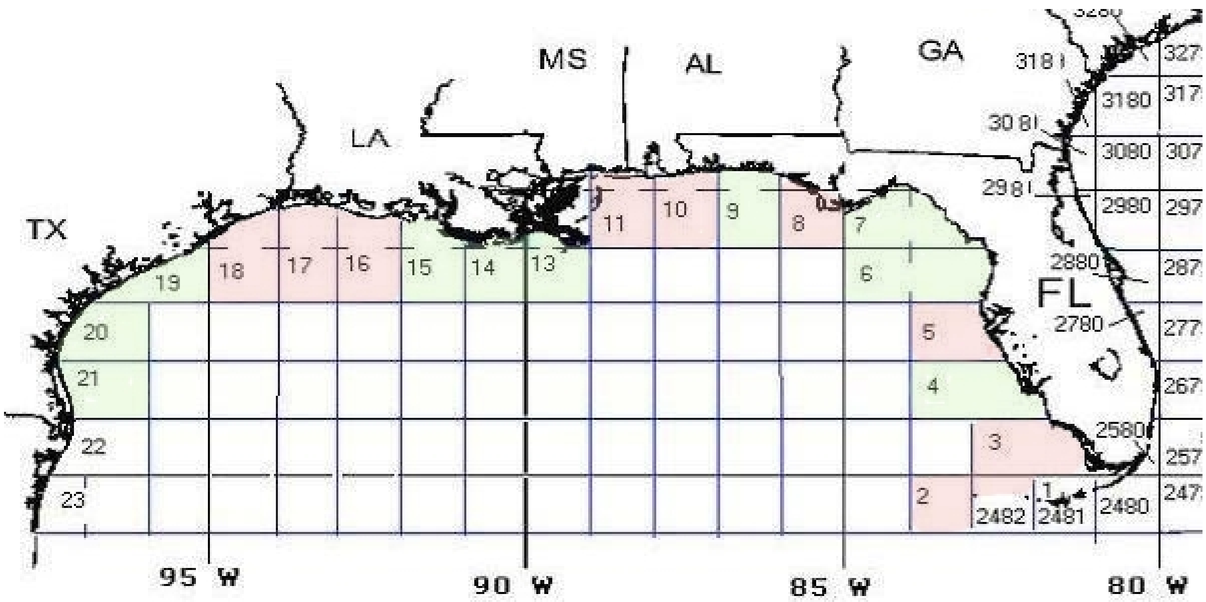
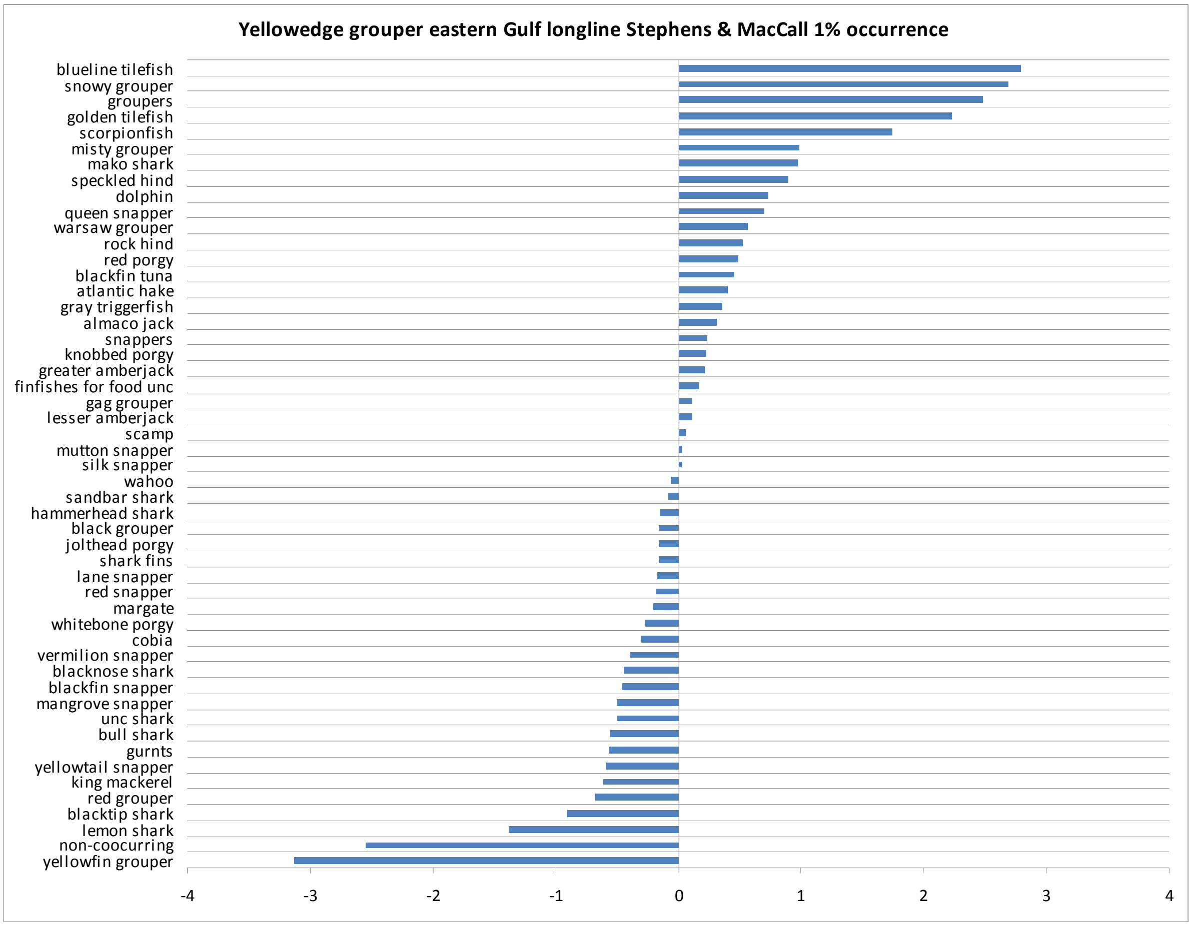


Figure 2. Regression coefficients from the Stephens & MacCall analyses. Positive coefficients signify species that had positive associations with the target species. The magnitude of the coefficients indicates the predictive impact of each species. The value for "non-coocurring" is the regression intercept and denotes the probability a trip was fishing in the target species' habitat, but did not report any of the listed species. Species included were reported on at least one percent of longline trips in the eastern or western Gulf of Mexico.

2A. Yellowedge grouper eastern Gulf of Mexico longline



2B. Yellowedge grouper western Gulf of Mexico longline

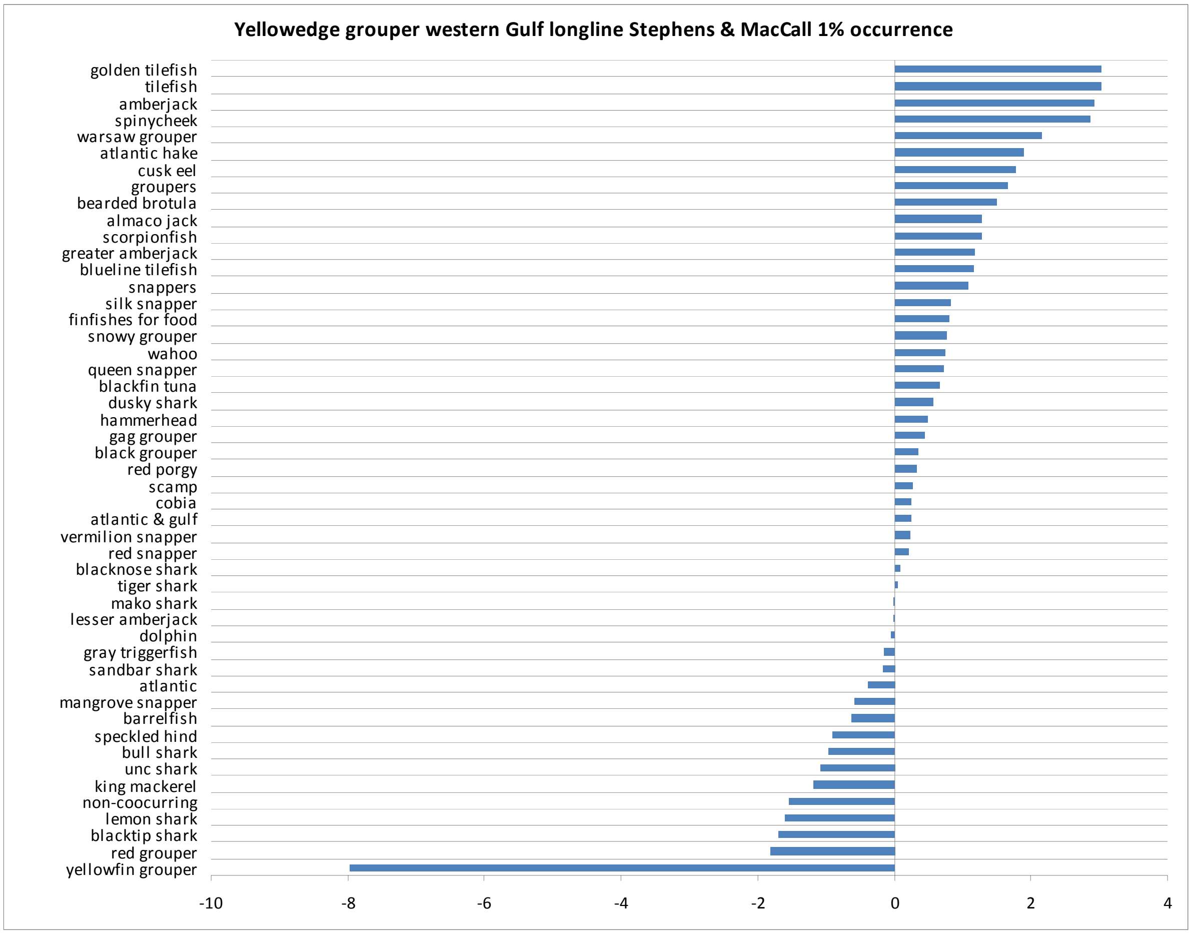


Figure 3. Yellowedge grouper nominal CPUE (solid circles), standardized CPUE (open diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dashed lines) for vessels fishing longline gear in the Gulf of Mexico.

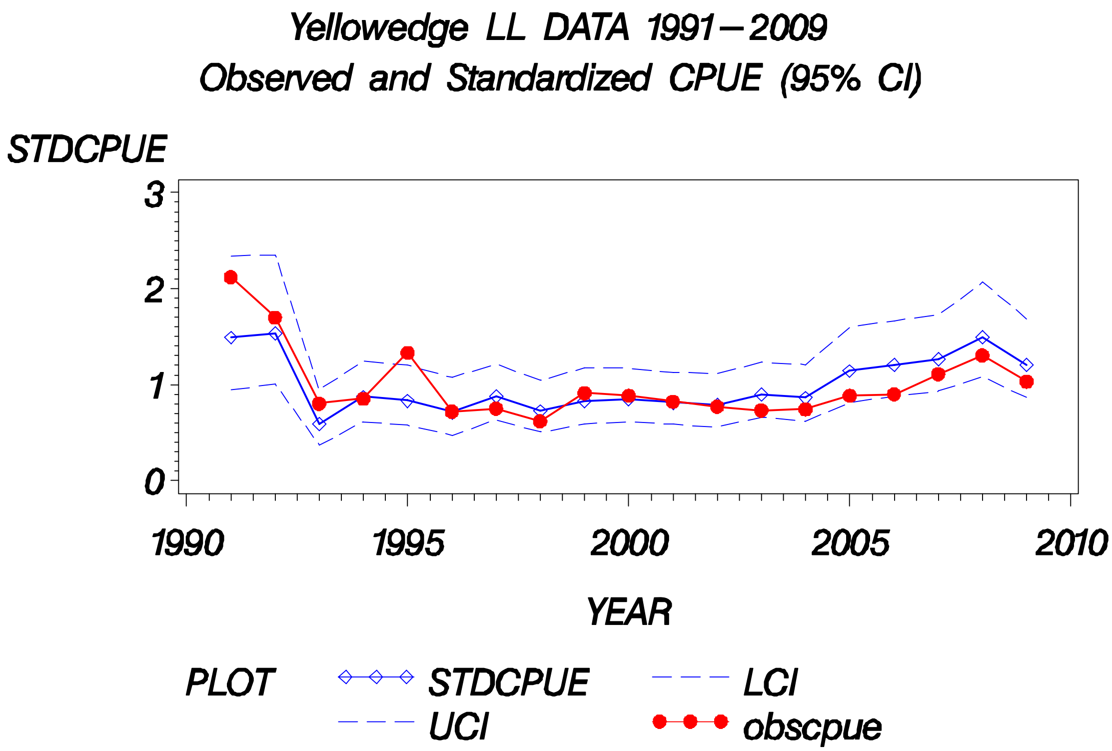
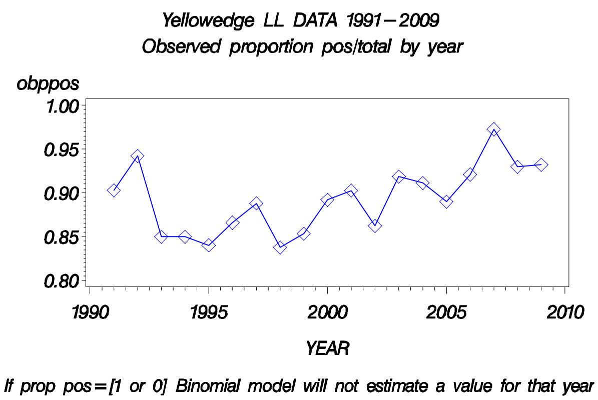


Figure 4. Annual trend in **A.** the proportion of positive trips and **B.** nominal CPUE for the Gulf of Mexico 1991-2009 yellowedge grouper commercial longline gear model.

A.



B.

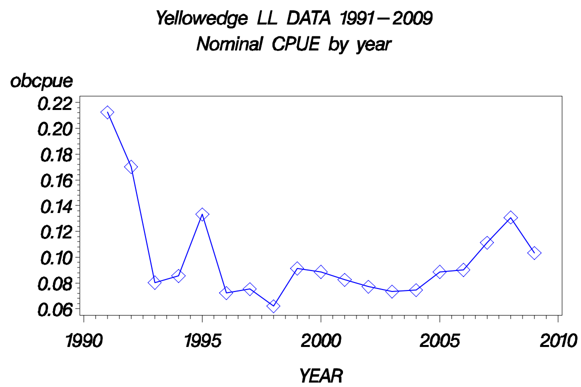
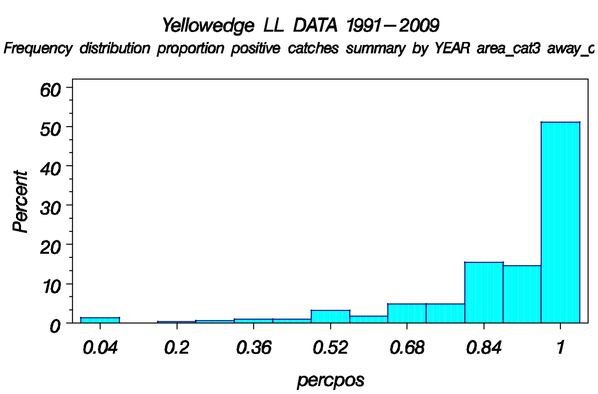


Figure 5. Diagnostic plots for the binomial component of the Gulf of Mexico 1991-2009 yellowedge grouper commercial longline gear model: **A**. the frequency distribution of the proportion positive trips; **B**. the Chi-Square residuals by year; **C**. the Chi-Square residuals by area (area_cat3); and **D**. the Chi-Square residuals by days at sea (away_cat).

A.



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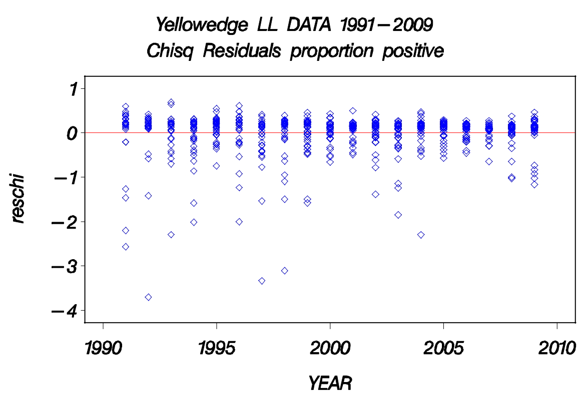
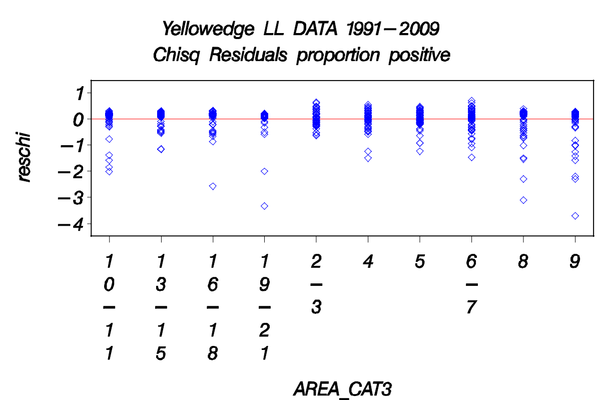


C.



D.

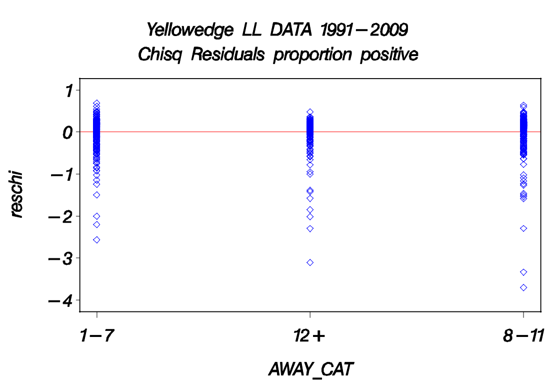
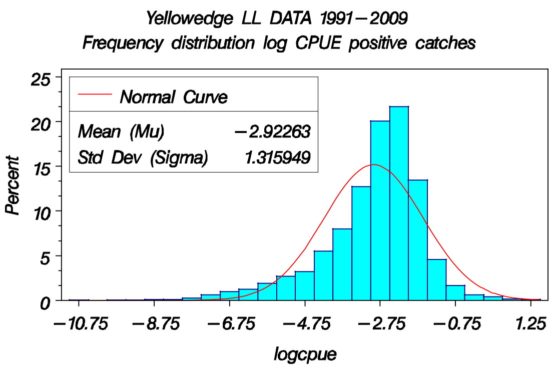


Figure 6. Diagnostic plots for the lognormal component of the Gulf of Mexico 1991-2009 yellowedge grouper commercial longline gear model: **A.** the frequency distribution of log(CPUE) on positive trips, **B.** the cumulative normalized residuals (QQ-Plot) from the lognormal model. The red line is the expected normal distribution.

A.



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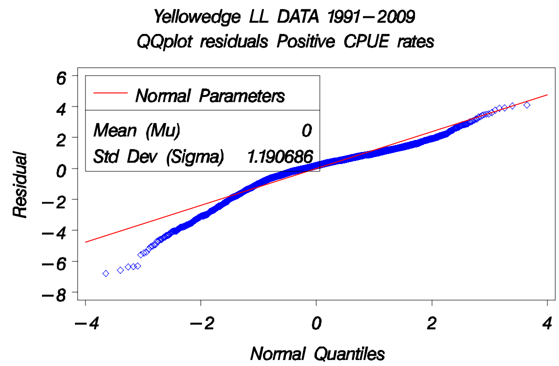
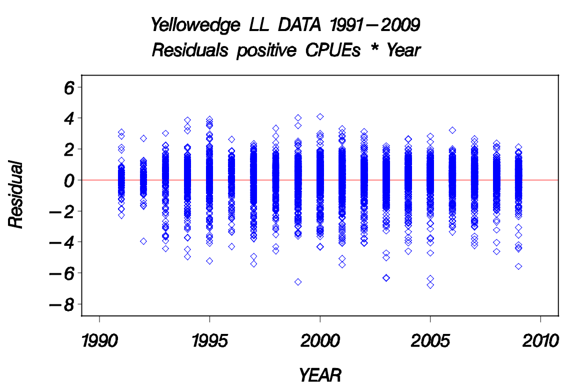


Figure 7. Diagnostic plots for the lognormal component of the Gulf of Mexico 1991-2009 yellowedge grouper commercial longline gear model: **A**. the Chi-Square residuals by year; **B**. the Chi-Square residuals by area (area_cat3); **C**. the Chi-Square residuals by distance between hooks (hook_cat);

A.



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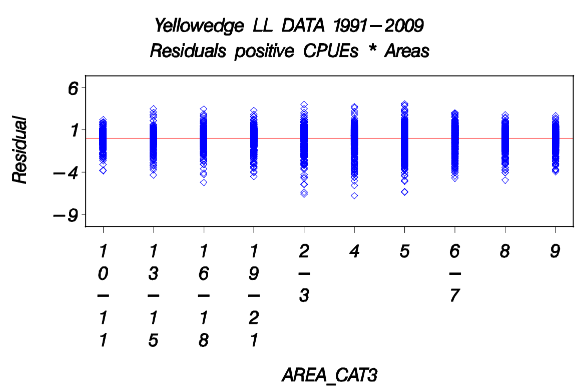

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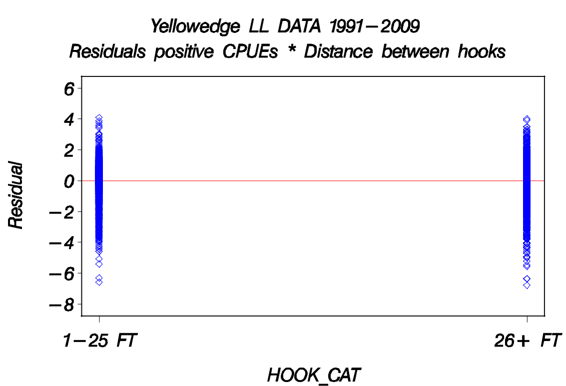

United States Commercial Longline Vessel Standardized Catch Rates of Yellowedge Grouper (*Epinephelus flavolimbatus*) in the Gulf of Mexico, 1991-2009: ADDENDUM

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Introduction

An initial fisheries dependent index of abundance was constructed using self-reported commercial longline logbook data (SEDAR22-DW-02), however during the data workshop it was recommended that the unusually high amount of yellowfin grouper (*Mycteroperca venenosa)* landings be reclassified as yellowedge grouper (*Epinephelus flavolimbatus*). That decision was based upon consultation with the panel's fishermen and other members. The results below are from the yellowedge-yellowfin landing adjustment dataset.

Methods

Available Data

Data description and refinement methods are described in SEDAR22-DW-02. To account for the misreporting, the panel had agreed to change most landings reported as yellowfin grouper to yellowedge grouper. This prompted change to 334 trips for all Gulf of Mexico longline trips between 1991 and 2009. There were an additional 44 trips that had reported both yellowfin and yellowedge groupers. In those instances, the SEDAR panel recommendation was to use the data as reported and no changes were made to the original data.

Once the yellowfin-yellowedge grouper adjustments were made, a new selection of yellowedge grouper trips was performed. The selection process using a data subsetting technique (modified from Stephens and McCall, 2004) is described in the original document. When applied to the revised data, the selection process yielded additional trips. The effect on the species coefficients (indicative of the predictive influence of a species in the selection procedure) was minimal, except for yellowfin grouper which dropped from the species list due to the species adjustments described above. Figure A-1 provides these species-specific regression coefficients.

Index Development

Methods used for index construction were the same as those reported in SEDAR22-DW-02. Factors that were considered as possible influences on longline proportion of trips that landed yellowedge grouper and the catch rate of yellowedge grouper were unchanged from the initial index, as was the calculation of CPUE. Determination of the set of fixed factors using a general linear model (GLM) analyses of the proportion positive trips and the catch rates on successful trips was unchanged. The creation of the final delta-lognormal model using a SAS macro, GLIMMIX (Russ Wolfinger, SAS Institute) also remained unchanged.

Results and Discussion

The final models for the binomial on proportion positive trips (PPT) and the lognormal on CPUE of successful trips were:

Yellowedge grouper longline 1991-2009:

PPT = Area + Days at Sea + Year

LOG(CPUE) = Area + Distance between Hooks + Year + Year*Area

The linear regression statistics and analysis of the mixed model formulations of the final models are summarized in Table A-1.

Relative nominal CPUE, number of trips, proportion positive trips, and relative abundance index are provided in Table A-2. The delta-lognormal abundance index developed, with 95% confidence intervals, is shown in Figure A-2.

Plots of the proportion of positive trips per year, nominal CPUE, frequency distributions of the proportion of positive trips, frequency distributions of log(CPUE) for positive catch, cumulative normalized residuals, and plots of chi-square residuals by each main effect for the binomial and lognormal models are shown in Figures A-3 through A-6. The diagnostic plots indicate that the fit of the data to the lognormal and binomial models was acceptable. There were some outliers among these data, however, and the frequency distribution of log(CPUE) from these data was somewhat skewed from the expected normal distribution. The variations from the expected fit of the data were not sufficient to violate assumptions of the analyses. The observed positive yellowedge grouper trips ranged from approximately 85 to 98% and were at the edge of the range required for analysis.

Yellowedge grouper standardized catch rates for longline vessels remained relatively constant from 1993 through 2002, rose steadily from 2004 through 2008, and dropped-off in 2009. Rates in 1991 and 1992 were notably higher; however this may be attributed to a lower number of trips and a few trips with high catch rates. Coefficients of variation ranged from 0.15-0.24, with a higher CV from 1991-1993, but were generally consistent over the rest of the time series. The higher initial CVs may have been due to smaller sample sizes (i.e. sampling error) prior to 1993, when only a subsample of vessels (20 percent) reported in Florida.

Table A-1. Linear regression statistics for the GLM models on proportion positive trips (**A**) and catch rates on positive trips (**B**) of yellowedge grouper in the Gulf of Mexico for vessels reporting longline gear landings 1991-2009. Analysis of the mixed model formulations of the positive trip model (**C**). The likelihood ratio was used to test the difference of –2 REM log likelihood between two nested models. The final model is indicated with gray shading. See text of SEDAR22-DW-02 for factor (effect) definitions.

A.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
YEAR	18	508	53.89	2.99	<.0001	<.0001
AREA_CAT3	9	508	148.16	16.46	<.0001	<.0001
AWAY_CAT	2	508	41.52	20.76	<.0001	<.0001

B.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
AREA_CAT3	9	162	176.22	19.58	<.0001	<.0001
HOOK_CAT	1	4802	97.53	97.53	<.0001	<.0001
YEAR	18	162	65.87	3.66	<.0001	<.0001

C.

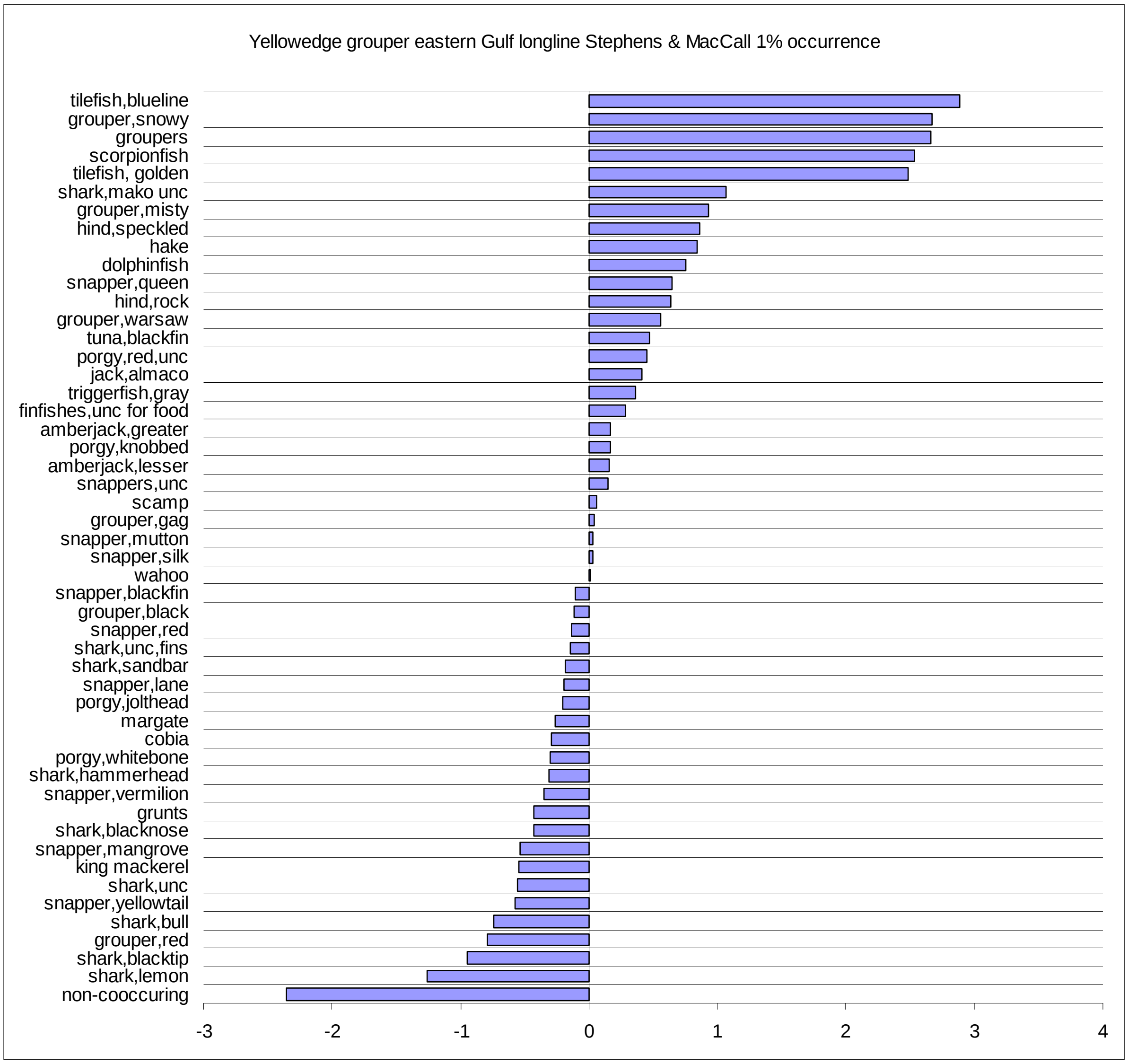
Catch Rates on Positive Trips	*-2 REM Log likelihood*	*Akaike's Information Criterion*	*Schwartz's Bayesian Criterion*	*Likelihood Ratio Test*	*P*
Year + Area + Hook_dist	16505.4	16507.4	16513.9	-	-
*Year + Area + Hook_dist + Year*Area*	**16452.3**	**16456.3**	**16462.8**	**53.1**	**<0.0001**

Table A-2. Longline relative nominal CPUE, number of trips, proportion positive trips, and relative abundance index for yellowedge grouper (1991-2009) in the Gulf of Mexico.

YEAR	Relative Nominal CPUE	Trips	Proportion Successful Trips	Relative Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1991	2.763221	116	0.922414	1.516128	0.984288	2.335337	0.218542
1992	1.562496	123	0.918699	1.449104	0.937928	2.238874	0.220112
1993	0.804279	174	0.867816	0.621648	0.389431	0.992335	0.237077
1994	0.812022	326	0.868098	0.912207	0.642000	1.296140	0.177003
1995	1.189826	344	0.848837	0.814693	0.563764	1.177309	0.185658
1996	0.701543	204	0.872549	0.668300	0.439352	1.016554	0.212045
1997	0.733037	367	0.901907	0.868919	0.625398	1.207265	0.165549
1998	0.630989	331	0.851964	0.747721	0.518602	1.078065	0.184488
1999	0.862710	389	0.858612	0.823427	0.576316	1.176493	0.179838
2000	0.868600	429	0.892774	0.835222	0.597652	1.167228	0.168523
2001	0.823798	408	0.906863	0.805724	0.577871	1.123420	0.167350
2002	0.740617	354	0.875706	0.783833	0.549460	1.118179	0.179041
2003	0.726188	440	0.925000	0.921541	0.670646	1.266299	0.159912
2004	0.706083	306	0.908497	0.854458	0.603201	1.210375	0.175437
2005	0.847371	279	0.892473	1.136052	0.806778	1.599713	0.172393
2006	0.863297	267	0.928839	1.220332	0.881659	1.689099	0.163616
2007	1.067990	258	0.980620	1.289692	0.947675	1.755143	0.154992
2008	1.248652	229	0.930131	1.485238	1.068224	2.065045	0.165914
2009	1.047280	223	0.946188	1.245760	0.889774	1.744171	0.169465

Figure A-1. Regression coefficients from the Stephens & McCall analyses for the **a)** eastern Gulf of Mexico and **b)** the western Gulf of Mexico. Positive coefficients signify species that had positive associations with the target species. The magnitude of the coefficients indicates the predictive impact of each species. The value for "non-coocurring" is the regression intercept and denotes the probability a trip was fishing in the target species' habitat, but did not report any of the listed species. Species included were reported on at least one percent of longline trips in the eastern or western Gulf of Mexico.

a. Yellowedge grouper eastern Gulf of Mexico longline



b. Yellowedge grouper western Gulf of Mexico longline

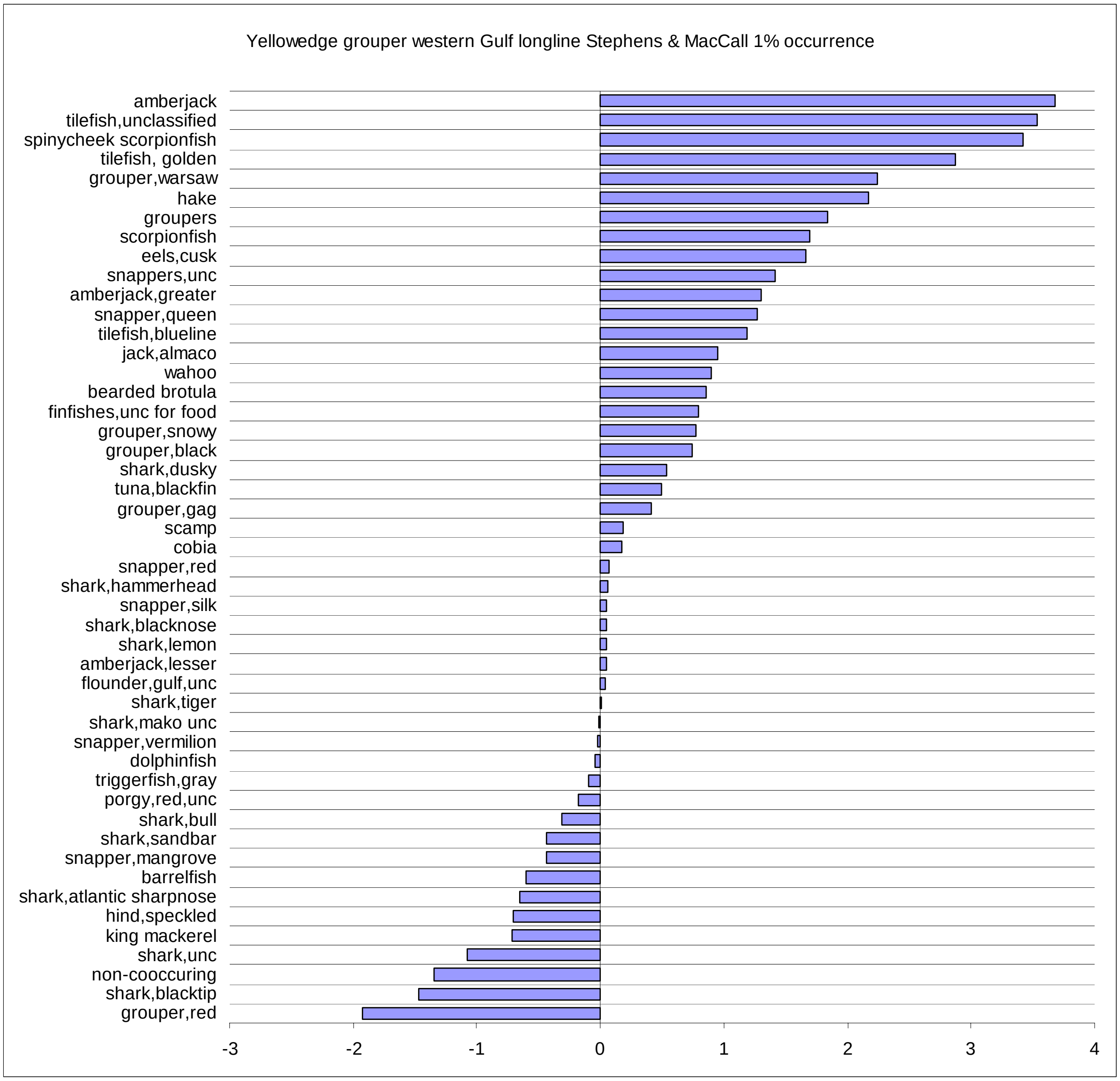


Figure A-2. Yellowedge grouper nominal CPUE (solid circles), standardized CPUE (open diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dashed lines) for vessels fishing longline gear in the Gulf of Mexico.

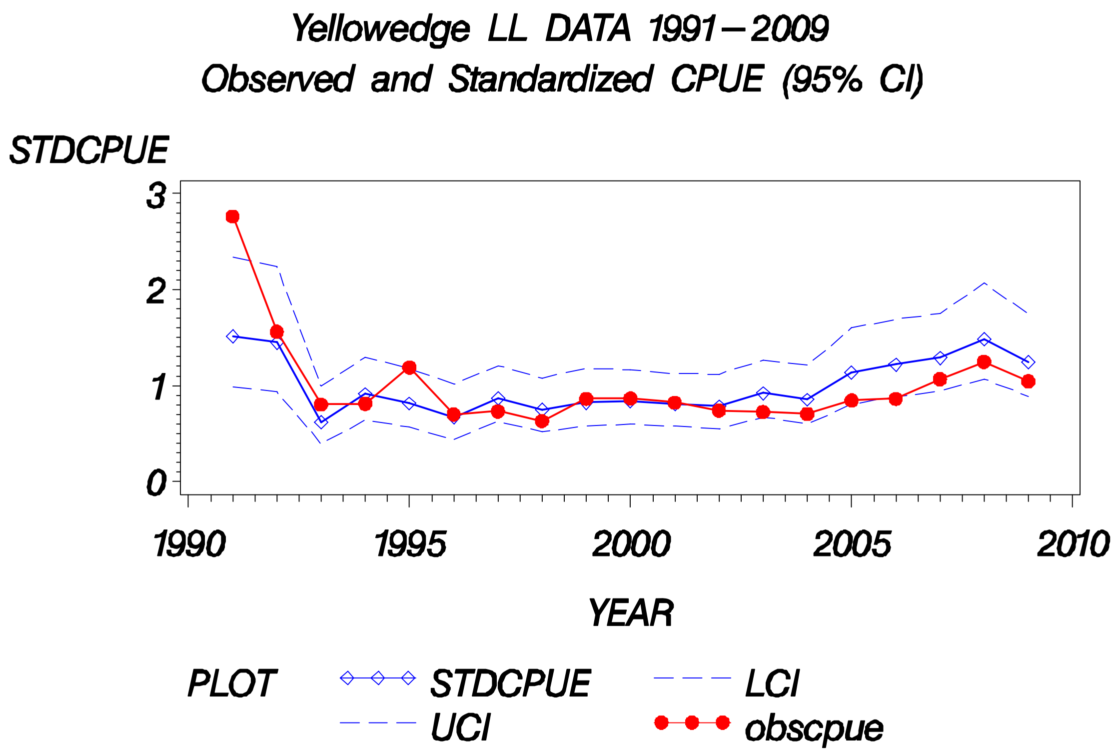
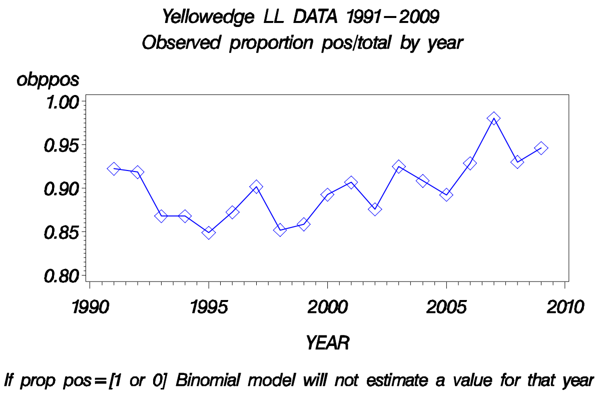


Figure A-3. Annual trend in **A.** the proportion of positive trips and **B.** nominal CPUE for the Gulf of Mexico 1991-2009 yellowedge grouper commercial longline gear model.

A.



B.

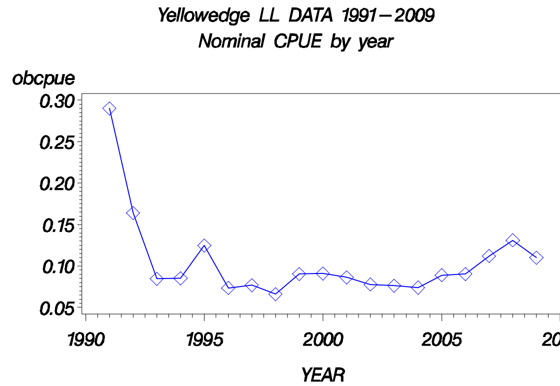
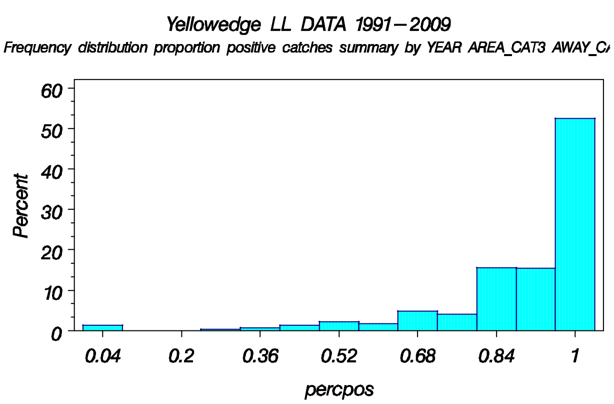
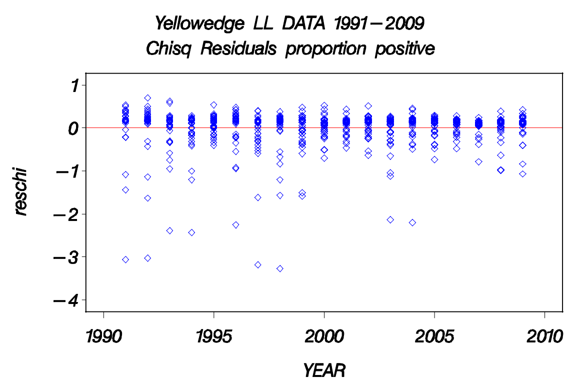


Figure A-4. Diagnostic plots for the binomial component of the Gulf of Mexico 1991-2009 yellowedge grouper commercial longline gear model: **A**. the frequency distribution of the proportion positive trips; **B**. the Chi-Square residuals by year; **C**. the Chi-Square residuals by area (area_cat3); and **D**. the Chi-Square residuals by number of hooks (hook_cat2). See SEDAR22-DW-02 for factor descriptions.

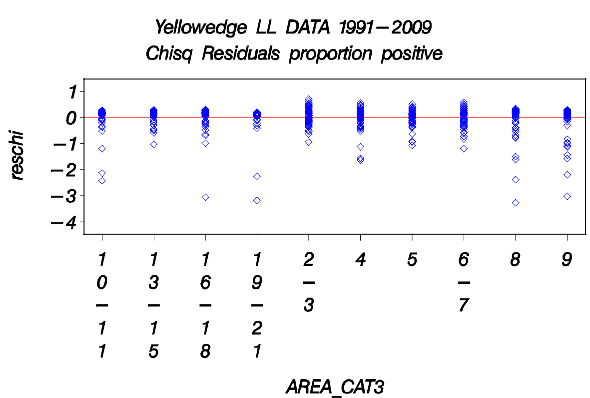
A.



B.



C.



D.

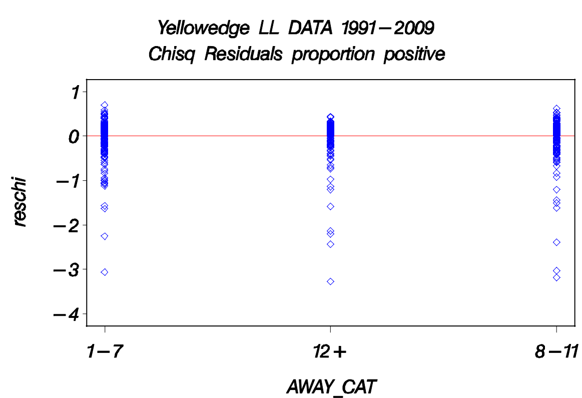
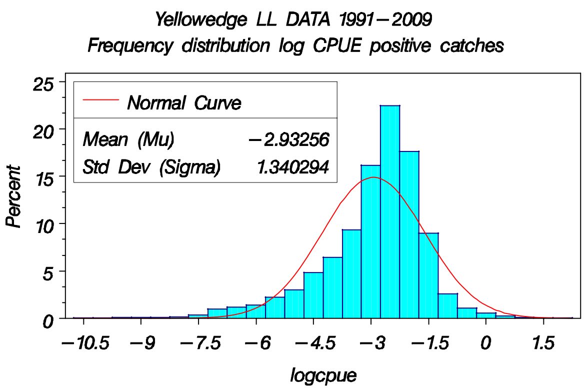


Figure A-5. Diagnostic plots for the lognormal component of the Gulf of Mexico 1991-2009 yellowedge grouper commercial longline gear model: **A.** the frequency distribution of log(CPUE) on positive trips, **B.** the cumulative normalized residuals (QQ-Plot) from the lognormal model. The red line is the expected normal distribution.

A.



B.

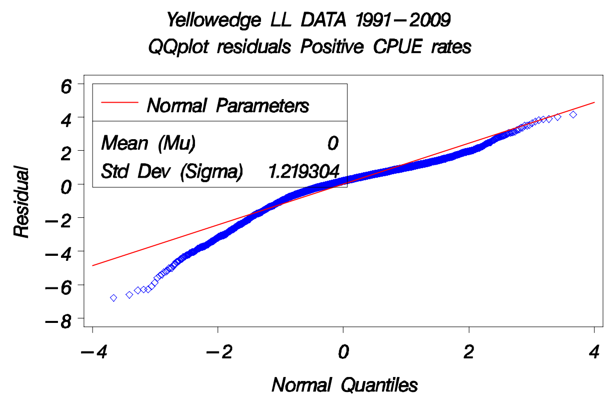
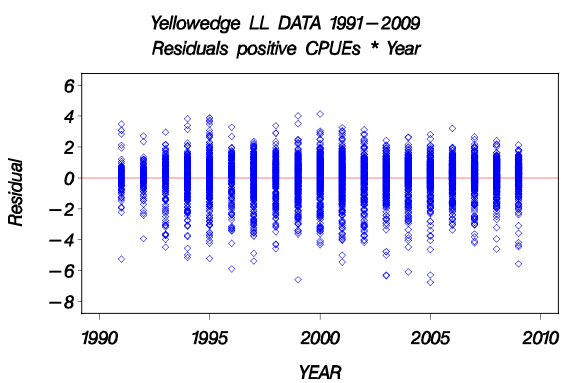
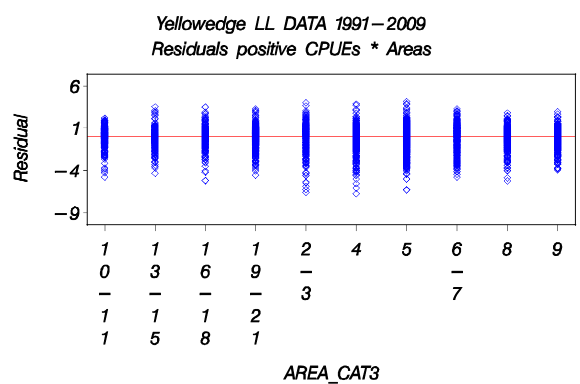


Figure A-6. Diagnostic plots for the lognormal component of the Gulf of Mexico 1991-2009 yellowedge grouper commercial longline gear model: **A**. the Chi-Square residuals by year; **B**. the Chi-Square residuals by area (area_cat3); **C**. the Chi-Square residuals by distance between hooks (hook_cat). See SEDAR22-DW-02 for factor descriptions.

A.



B.



C.