United States Commercial Longline Vessel Standardized Catch Rates of Golden and Blueline Tilefish in the Gulf of Mexico, 1992-2009: Revised

Kevin McCarthy

National Marine Fisheries Service, Southeast Fisheries Science Center
Sustainable Fisheries Division, 75 Virginia Beach Drive, Miami, FL, 33149-1099
Kevin.J.McCarthy@noaa.gov
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Introduction

During the SEDAR 22 data workshop, the indices working group in consultation with the assessment biologists recommended revising the commercial indices. Those revisions were to include subdividing the Gulf of Mexico into regions and constructing separate indicies for each region. In addition, golden tilefish were assumed not to occur south of area six in the eastern Gulf of Mexico (see Figure 1) and that no index including data from areas one-five was to be constructed for that species. It was further recommended in plenary session that yellowfin grouper were misreported and should be considered yellowedge grouper for these analyses. Such reclassification may have affected data subsetting using the Stephens and MacCall (2004) method. This document describes construction of those new indices recommended for golden and blueline tilefish.

Methods

Available Data

As described in McCarthy (2010), the coastal logbook self-reported commercial fishing data were used in the construction of indices of abundance for golden tilefish and blueline tilefish. Data filtering followed the methods described in McCarthy (2010). Briefly, data included in these analyses were restricted to trips which reported one area (i.e. statarea, as defined below) and one gear fished (bottom longline only). In addition, data were further restricted to include only those trips with landings and effort data reported within 45 days of the completion of the trip and clear outliers in the data, i.e. values falling outside the 99.5 percentile of the data, were excluded from the analyses. Finally, data from closed seasons were also excluded from the analyses.

Separate golden tilefish indices were constructed for two regions within the Gulf of Mexico. Those regions (areas 6-11 and 13-21, Figure 1) were identified based upon the available data. Further subsetting the data by area/region would have reduced sample size to such an extent that analyses may have been compromised. A blueline tilefish data set was constructed that included data from areas 2-6. Data from other areas were excluded from the blueline tilefish analysis due to their rare occurrence.

Golden and blueline tilefish trips were separately identified for each region (as defined above) following the methods of McCarthy (2010). For these analyses, however, the SEDAR 22 plenary decision that yellowfin grouper were misreported and should be assumed to be yellowedge grouper was followed. After reclassifying yellowfin grouper as yellowedge grouper, the data subsetting technique (modified from Stephens and MacCall, 2004) was followed as described in the data workshop document.

Index Development

As with the Gulf-wide indices constructed for the data workshop, eight factors were considered as possible influences on longline proportion of trips that landed tilefish and on the catch rate of tilefish. An additional factor, number of hooks fished, was examined for its affect on the proportion of positive trips. In order to

develop a well balanced sample design it was necessary to define categories within some of the factors examined:

Golden tilefish – northeastern Gulf of Mexico

Factor	Levels	Value
Year	18	1992-2009
Season	4	Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec
Subregion	3	Statistical areas 6-8, 9, 10-11 see Figure 1
Longline length (ll_length)*	3	1-3.5, 3.6-5, >5 miles
Days at sea (seadays)*	3	1-5, 6-8, >8 days
Crew (crew1)*	3	1-2, 3, 4-6 crew members
Distance between hooks (hk_dist1)*	3	<22, 22-31.5, >31.5 feet
Hooks fished (hks_fished)*[1]	3	<8,401; 8,401-19,200; >19,200 hooks

* Names in parentheses appear in some figures and tables.
[1] Hooks fished was examined only for the proportion positive analyses.

Golden tilefish – western Gulf of Mexico

Factor	Levels	Value
Year	17	1992-2008
Season	4	Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec
Subregion	3	Statistical areas 13-15, 16-18, 19-21 see Figure 1
Longline length (ll_length)*	3	1-3, 3.1-5.6, >5.6 miles
Days at sea (seadays)*	3	1-7, 8-11, >11 days
Crew (crew1)*	2	1-3, 4-6 crew members
Distance between hooks (hk_dist1)*	3	<22, 22-26.4, >26.4 feet
Hooks fished (hks_fished)*[1]	3	<14,501; 14,501-36,000; >36,000 hooks

* Names in parentheses appear in some figures and tables.
[1] Hooks fished was examined only for the proportion positive analyses.

Blueline tilefish

Factor	Levels	Value
Year	17	1993-2009
Season	4	Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec
Subregion	5	Statistical areas 2-3, 4, 5, 6 see Figure 1.
Longline length (ll_length)*	4	1-4.6, 4.7-5.7, 5.8-7, 7+ miles
Days at sea (seadays)*	3	1-9, 10-12, 13-20 days
Crew (crew1)*	3	1-2, 3, 4-6 crew members
Distance between hooks (hk_dist1)*	3	<21, 21-29.1, >29.1 feet
Hooks fished (hks_fished)*[1]	3	<19,001, 19,001-35,000, >35,000 hooks

* Names in parentheses appear in some figures and tables.
[1] Hooks fished was examined only for the proportion positive analyses.

Significant affects on the proportion of positive trips and on the CPUE of positive trips of the above factors were tested using general linear model (GLM) analyses, as in McCarthy (2010). The delta-lognormal model approach (Lo et al. 1992) was used to construct standardized indices of abundance, see McCarthy (2010) for additional details.

Results and Discussion

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

Golden tilefish – northeastern Gulf of Mexico:

PPT = Year + Subregion + Distance Between Hooks

LOG(CPUE) = Days at Sea + Year + Subregion + Subregion*Year + Days at Sea*Year

In the proportion positive analysis, when the two-way interactions Year*Distance Between Hooks and Year*Subregion were tested, the model failed to converge. Those interaction terms were excluded from further analyses. The linear regression statistics and analysis of the mixed model formulations of the final models are summarized in Table 1.

Golden tilefish – western Gulf of Mexico:

PPT = Days at Sea + Subregion + Year

LOG(CPUE) = Distance Between Hooks + Subregion + Year + Crew1

In the proportion positive analysis the factor Year was not significant. Year was included in the final model, however. No two interactions involving Year were tested. The linear regression statistics and analysis of the mixed model formulations of the final models are summarized in Table 2.

Blueline tilefish:

PPT = Subregion + Year

LOG(CPUE) = Distance Between Hooks + Subregion + Year + Distance Between Hooks*Year

The linear regression statistics of the final GLM models are summarized in Table 3.

Relative nominal CPUE, number of trips, proportion positive trips, and standardized abundance indices are provided in Tables 4-6 for the golden tilefish and blueline tilefish models. The delta-lognormal abundance indices developed for each species, with 95% confidence intervals, are shown in Figures 2-4.

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 (QQ plots), and plots of chi-square residuals by each main effect for the binomial and lognormal models are shown in Figures 5-8 (golden tilefish, northeastern Gulf), Figures 9-12 (golden tilefish, western Gulf), and Figures 13-16 (blueline tilefish, eastern Gulf). Those diagnostic plots indicate that the fit of the data to the lognormal models was acceptable, although frequency distributions of log(CPUE) data for each species and region were slightly skewed from the expected normal distribution. Fits of the data to the binomial model were, perhaps, less satisfactory due to the high proportion of positive trips. There were some outliers among these data, but those variations from the expected fit of the data did not appear to be sufficient to violate assumptions of the analyses. The observed positive golden tilefish trips ranged from approximately 64 to 96% in the northeastern Gulf of Mexico and between 68 and 92% in the western Gulf of Mexico. Data from both regions were within the acceptable range required for the analysis. Blueline tilefish percent positive trips were also within the range appropriate for the analysis (59-92%).

Golden tilefish standardized catch rates for longline vessels in the northeastern Gulf of Mexico had a general increase over the first eight years of the time series, decreased after 1999, and began increasing again after 2003. In the western Gulf of Mexico, golden tilefish standardized CPUE increased during the initial five years of the time series, but had no clear trend over time after 1996. Mean annual CPUE often had large increases and decreases between years, particularly during the period 2001-2008. Coefficients of variation (CV) were in the range 0.36-0.53 in the northeastern Gulf of Mexico, but were lower in the western Gulf in most years (0.19-0.62, usually less than 0.3). In both regions, CVs were higher in years with lower sample size.

Blueline tilefish CPUE also increased during the first five to six years of the time series followed by no clear trend from 1998-2003. Yearly standardized CPUE increased from 2003 to 2008, but decreased again in 2009. CVs and confidence intervals for blueline tilefish in the eastern Gulf of Mexico were much lower than for the initial Gulf-wide index constructed for the data workshop (see McCarthy, 2010). CVs for the blueline tilefish eastern Gulf of Mexico index ranged from 0.36-0.52.

To the extent that the available data allowed, indices for both tilefish species were constructed following the recommendations of the index working group, recommendations from plenary sessions, and advice of the assessment biologists. In the northeastern Gulf of Mexico, golden tilefish CPUE has increased during the final six years of the time series of available data. In the western Gulf of Mexico, golden tilefish commercial longline CPUE has had no clear trend since 1996. Limiting the blueline tilefish data to the eastern Gulf of Mexico clearly improved the analysis over the Gulf-wide analysis completed for the data workshop. The eastern Gulf index had smaller confidence intervals and CVs than the earlier Gulf-wide index, although the trends in CPUE were similar. Such lower variability associated with the eastern Gulf of Mexico index allows for much greater confidence in the observed recent increase in blueline tilefish CPUE.

Literature Cited

Littell, R.C., G.A. Milliken, W.W. Stroup, and R.D Wolfinger. 1996. SAS® System for Mixed Models, Cary NC, USA:SAS Institute Inc., 1996. 663 pp.

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 golden tilefish in the northeastern Gulf of Mexico for vessels reporting longline gear landings 1992-2009. 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	17	137	25.96	1.53	0.0752	0.0938
subregion	2	137	19.49	9.75	<.0001	0.0001
hk_dist1	2	137	11.18	5.59	0.0037	0.0046

B.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	17	34	27.40	1.61	0.0525	0.1157
seadays	2	34	36.52	18.26	<.0001	<.0001
subregion	2	34	18.32	9.16	0.0001	0.0007

C.

Catch Rates on Positive Trips	*-2 REM Log likelihood*	*Akaike's Information Criterion*	*Schwartz's Bayesian Criterion*	*Likelihood Ratio Test*	*P*
seadays + year + subregion	6603.1	6605.1	6610.5	-	-
*seadays + year + subregion + year*subregion*	6581.6	6585.6	6589.5	21.5	<0.0001
*seadays + year + subregion + year*subregion + seadays*year*	6574.7	6580.7	6586.5	6.9	0.0086

Table 2. Linear regression statistics for the GLM models on proportion positive trips (**A**) and catch rates on positive trips (**B**) of golden tilefish in the western Gulf of Mexico for vessels reporting longline gear landings 1992-2009. 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	16	116	13.17	0.82	0.6601	0.6570
seadays	2	116	27.14	13.57	<.0001	<.0001
subregion	2	116	18.63	9.31	<.0001	0.0002

B.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	17	655	47.07	2.77	0.0001	0.0002
hk_dist1	2	655	52.72	26.36	<.0001	<.0001
subregion	2	655	25.62	12.81	<.0001	<.0001
crew1	1	655	18.71	18.71	<.0001	<.0001

C.

Catch Rates on Positive Trips	*-2 REM Log likelihood*	*Akaike's Information Criterion*	*Schwartz's Bayesian Criterion*	*Likelihood Ratio Test*	*P*
hk_dist1 + subregion + year + crew1	2446.9	2448.9	2453.4	-	-
*hk_dist1 + subregion + year + crew1 + year*crew1*	2443.2	2447.2	2450.3	3.7	0.0544

Table 3. Linear regression statistics for the GLM models on proportion positive trips (**A**) and catch rates on positive trips (**B**) for blueline tilefish in the eastern Gulf of Mexico for vessels reporting longline gear landings 1993-2009. 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	16	48	30.50	1.91	0.0156	0.0435
subregion	3	48	76.37	25.46	<.0001	<.0001

B.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	16	32	23.83	1.49	0.0934	0.1646
hk_dist1	2	32	43.95	21.98	<.0001	<.0001
subregion	3	983	34.89	11.63	<.0001	<.0001

C.

Catch Rates on Positive Trips	*-2 REM Log likelihood*	*Akaike's Information Criterion*	*Schwartz's Bayesian Criterion*	*Likelihood Ratio Test*	*P*
hk_dist1 + subregion + year	3778.6	3780.6	3785.5	-	-
*hk_dist1 + subregion + year + hk_dist1*year*	3771.9	3775.9	3779.7	6.7	0.0096
*hk_dist1 + subregion + year + hk_dist1*year + subregion*year*	3771.7	3777.7	3783.5	0.2	0.6547

Table 4. Longline relative nominal CPUE, number of trips, proportion positive trips, and standardized abundance index for golden tilefish (1992-2009) in the northeastern Gulf of Mexico.

YEAR	Relative Nominal CPUE	Trips	Proportion Successful Trips	Standardized Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1992	0.808168	36	0.638889	0.388729	0.143678	1.05173	0.530117
1993	0.605757	37	0.702703	0.497613	0.192277	1.287827	0.503621
1994	1.240744	87	0.908046	0.933917	0.437785	1.992305	0.392837
1995	1.288142	114	0.850877	1.073418	0.50398	2.286253	0.39195
1996	0.797933	85	0.847059	0.679338	0.314567	1.467098	0.399674
1997	1.077343	150	0.9	0.887044	0.431272	1.82448	0.372622
1998	1.53512	122	0.893443	1.949293	0.929913	4.086129	0.383105
1999	1.359205	112	0.928571	1.820877	0.87275	3.79902	0.380499
2000	1.136415	184	0.826087	0.880235	0.423097	1.831289	0.37893
2001	0.887623	169	0.899408	0.685054	0.329738	1.423251	0.378164
2002	0.832265	172	0.895349	0.721522	0.35306	1.474521	0.369082
2003	1.10767	209	0.894737	0.569123	0.280519	1.154651	0.365087
2004	0.591844	107	0.915888	0.651857	0.310489	1.368543	0.383961
2005	0.487798	91	0.824176	0.769378	0.357524	1.655673	0.397697
2006	0.904974	92	0.826087	1.201616	0.555094	2.601149	0.400994
2007	1.340244	92	0.956522	1.338506	0.637991	2.808188	0.383578
2008	0.947888	79	0.886076	1.548395	0.703853	3.406288	0.410024
2009	1.050867	63	0.952381	1.404083	0.646142	3.051109	0.403139

Table 5. Longline relative nominal CPUE, number of trips, proportion positive trips, and standardized abundance index for golden tilefish (1992-2009) in the western Gulf of Mexico. No standardized index could be calculated for 2009, see text for details.

YEAR	Relative Nominal CPUE	Trips	Proportion Successful Trips	Standardized Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1992	0.520799	38	0.684211	0.360185	0.180145	0.720163	0.357088
1993	0.474943	56	0.732143	0.487979	0.284279	0.837639	0.275162
1994	1.143086	60	0.816667	0.58778	0.360715	0.957779	0.247816
1995	1.083581	94	0.840426	0.839468	0.566422	1.244136	0.198633
1996	1.064837	52	0.903846	1.527204	0.947572	2.461398	0.242084
1997	1.627245	44	0.840909	1.309518	0.752506	2.278836	0.282402
1998	0.465451	42	0.785714	0.642435	0.361622	1.14131	0.293367
1999	0.931828	92	0.73913	0.917622	0.60881	1.383078	0.207317
2000	0.711241	69	0.782609	0.907543	0.571137	1.442095	0.234695
2001	1.817395	50	0.82	1.07143	0.644539	1.78106	0.258265
2002	1.188452	46	0.913043	1.661245	1.014101	2.721363	0.250588
2003	0.373373	54	0.87037	0.638169	0.398957	1.020813	0.238152
2004	0.763357	31	0.774194	1.031528	0.542679	1.960738	0.3296
2005	1.3982	37	0.756757	2.052591	1.110229	3.79483	0.314666
2006	0.525543	26	0.692308	0.676625	0.320755	1.427323	0.386601
2007	0.707631	9	0.777778	1.386001	0.443947	4.327088	0.618618
2008	0.847239	24	0.916667	0.902676	0.453304	1.797523	0.35487
2009*	2.355798	15	1.0				

*2009 standardized index could not be calculated (see text for details)

Table 6. Longline relative nominal CPUE, number of trips, proportion positive trips, and relative abundance index for blueline tilefish (1993-2009) in the eastern Gulf of Mexico.

Year	Relative Nominal CPUE	Trips	Proportion Successful Trips	Standardized Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1993	0.582659	34	0.588235	0.373297	0.139481	0.999066	0.523599
1994	0.318289	79	0.721519	0.66986	0.31335	1.431985	0.394
1995	1.729223	69	0.652174	0.812245	0.355945	1.853494	0.4307
1996	0.900865	35	0.6	0.47001	0.180096	1.226619	0.508585
1997	0.90834	116	0.732759	1.092723	0.540318	2.209888	0.363338
1998	0.790939	93	0.741935	1.020981	0.482738	2.159352	0.388048
1999	0.665002	82	0.609756	0.582536	0.261538	1.297511	0.417004
2000	1.136305	94	0.734043	1.453171	0.695492	3.036279	0.381307
2001	0.575492	117	0.649573	0.621712	0.298247	1.295993	0.380019
2002	0.855135	72	0.680556	0.972063	0.444958	2.123585	0.406118
2003	0.734527	107	0.738318	0.62422	0.305347	1.276092	0.369263
2004	1.270115	98	0.744898	1.053631	0.506824	2.190382	0.378514
2005	1.052884	89	0.696629	1.089242	0.503899	2.354534	0.400198
2006	1.264341	112	0.741071	1.362462	0.673254	2.757209	0.363698
2007	1.554694	75	0.746667	1.490972	0.700168	3.174949	0.391837
2008	1.574642	87	0.91954	2.005069	0.987161	4.072587	0.365715
2009	1.086549	78	0.807692	1.305807	0.627063	2.719233	0.379451

Figure 1. Coastal Logbook defined fishing areas.

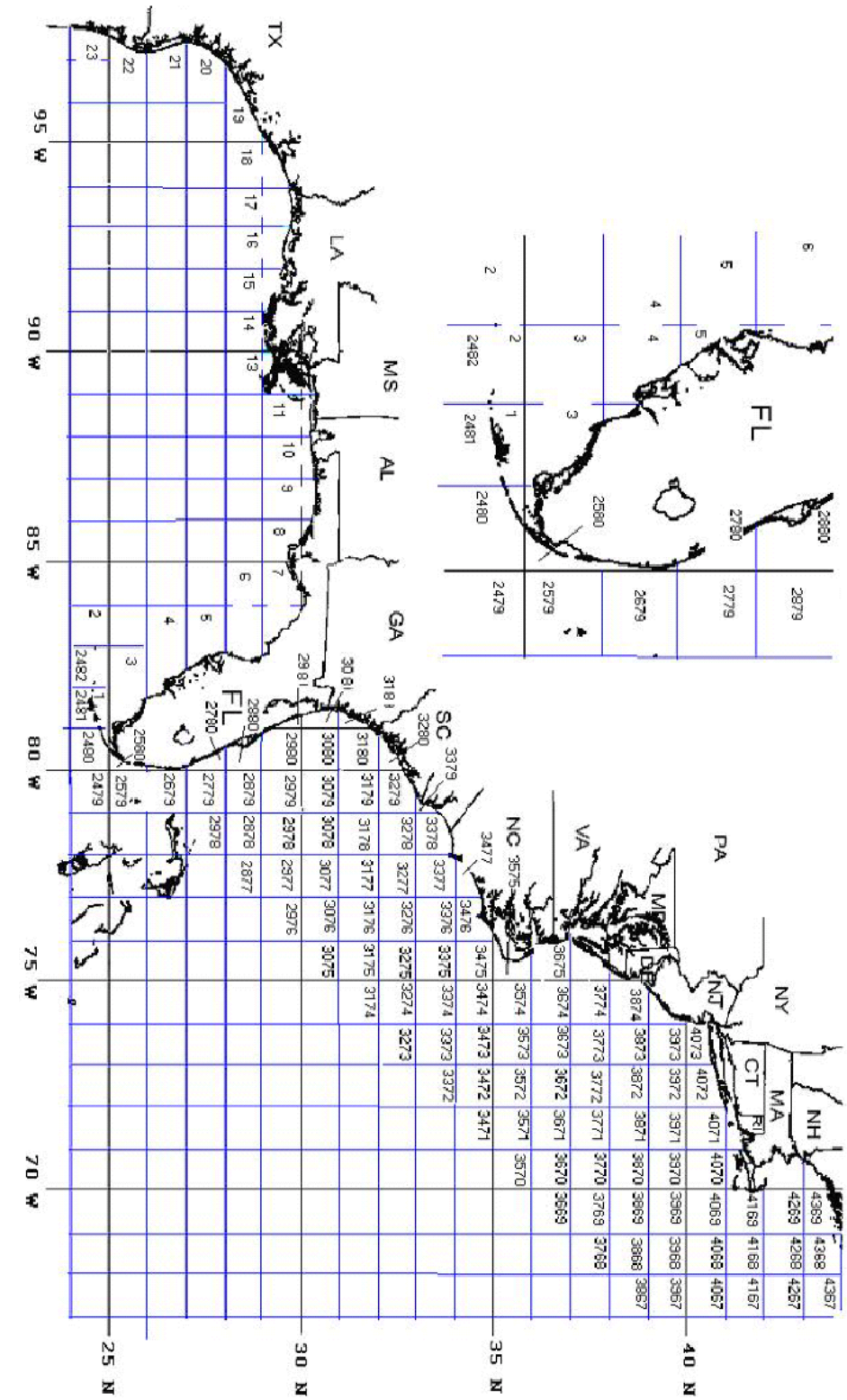


Figure 2. Golden tilefish nominal CPUE (solid circles), standardized CPUE (open diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dashed lines) for vessels fishing longline gear in the northeastern Gulf of Mexico.

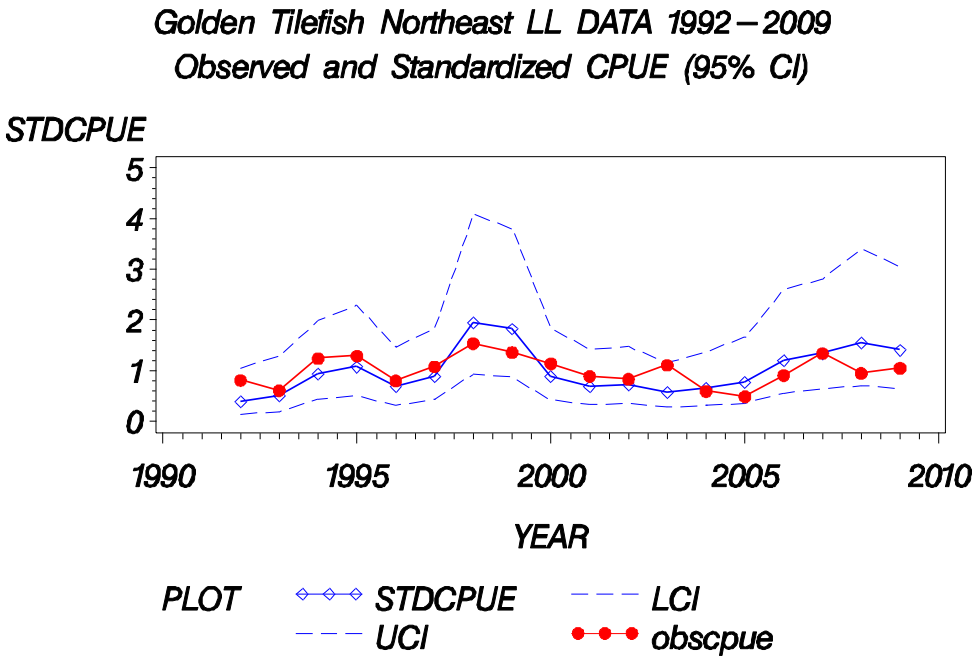


Figure 3. Golden tilefish nominal CPUE (solid circles), standardized CPUE (open diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dashed lines) for vessels fishing longline gear in the western Gulf of Mexico. Only positive trips were identified for 2009 using the Stephens and MacCall (2004) method, therefore, no standardized index could be calculated for that year.

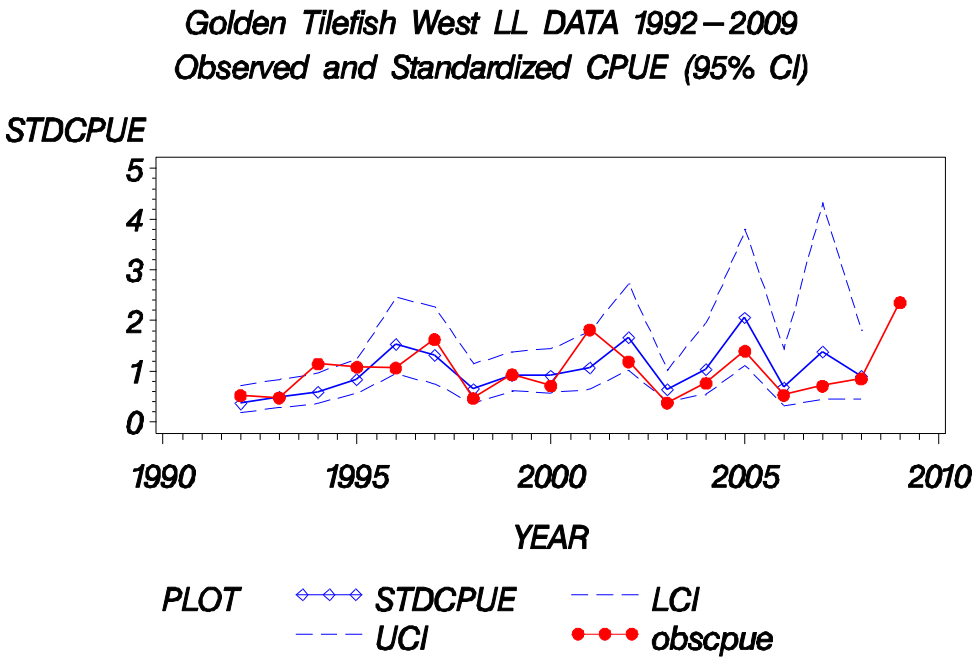


Figure 4. Blueline tilefish nominal CPUE (solid circles), standardized CPUE (open diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dashed lines) for vessels fishing longline gear in the eastern Gulf of Mexico.

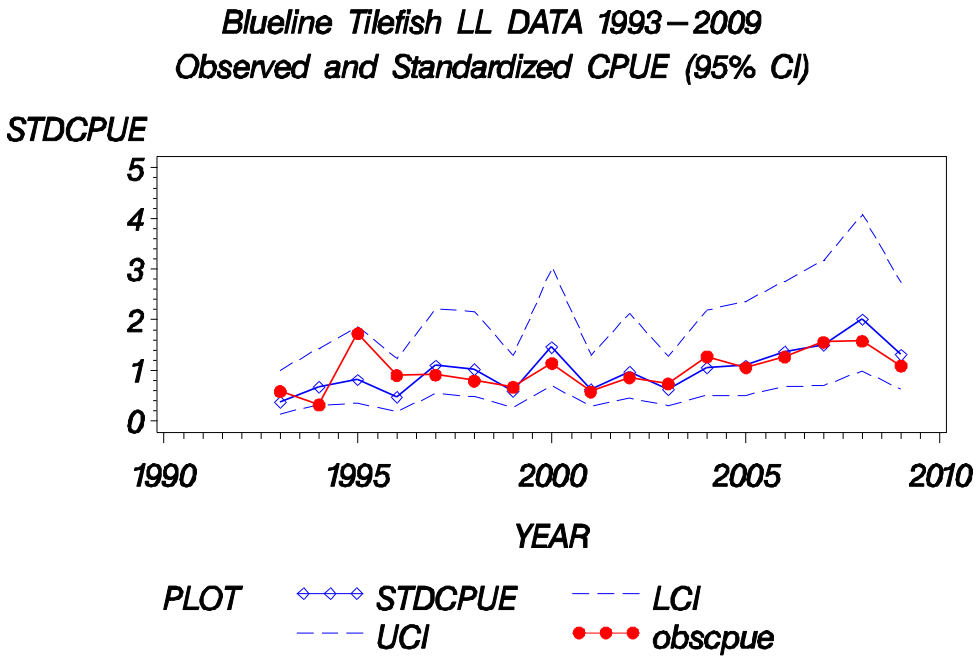
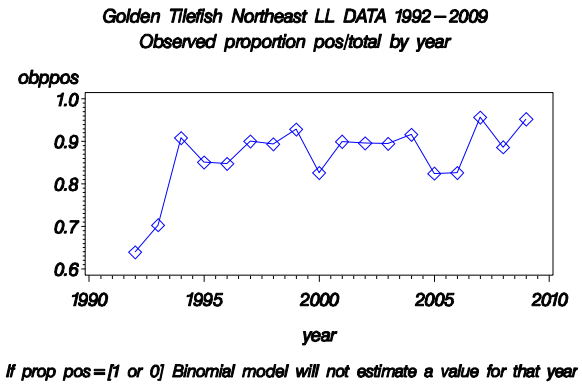


Figure 5. Annual trend in **A.** the proportion of positive trips and **B.** nominal CPUE of the northeastern Gulf of Mexico 1992-2009 golden tilefish commercial longline gear data.

A.



B.

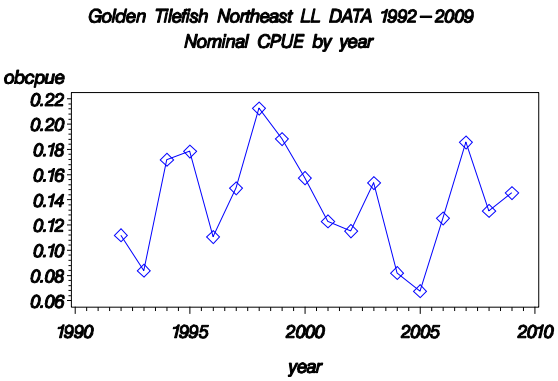
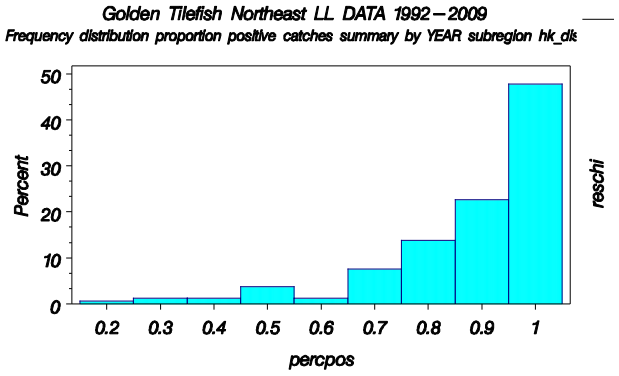
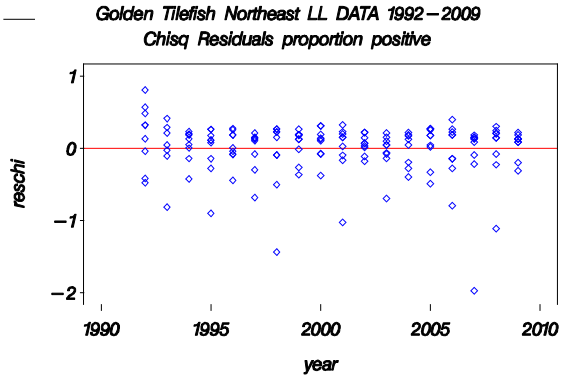


Figure 6. Diagnostic plots for the binomial component of the northeastern Gulf of Mexico 1992-2009 golden tilefish commercial longline gear model: **A**. the frequency distribution of the proportion positive trips; **B**. the Chi-Square residuals by year; **C**. the Chi-Square residuals by subregion; and **D**. the Chi-Square residuals by days at sea.

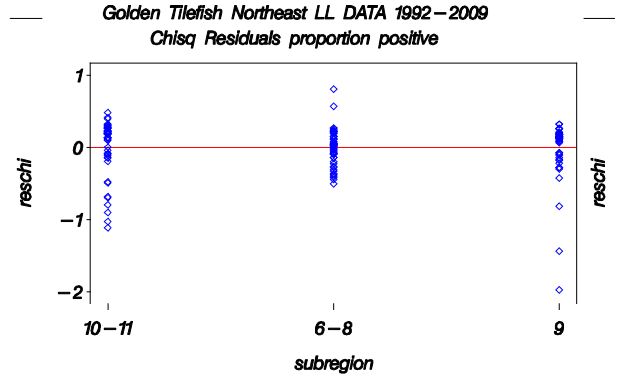
A.



B.



C.



D.

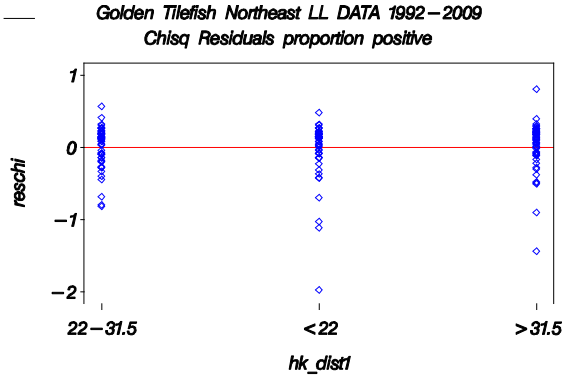
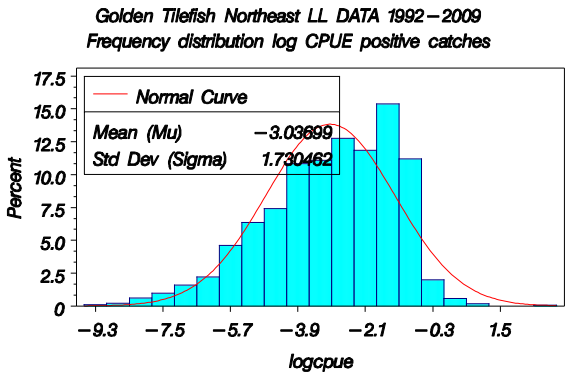


Figure 7. Diagnostic plots for the lognormal component of the northeastern Gulf of Mexico 1992-2009 golden tilefish commercial longline gear model: **A.** the frequency distribution of log(CPUE) on positive trips, **B.** the cumulative normalized residuals (QQ-Plot) from the lognormal model. The red line is the expected normal distribution.

A.



B.

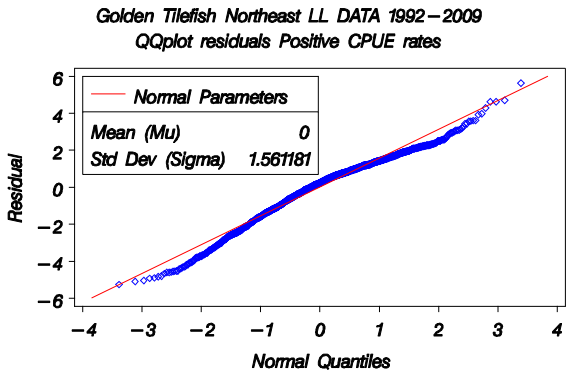
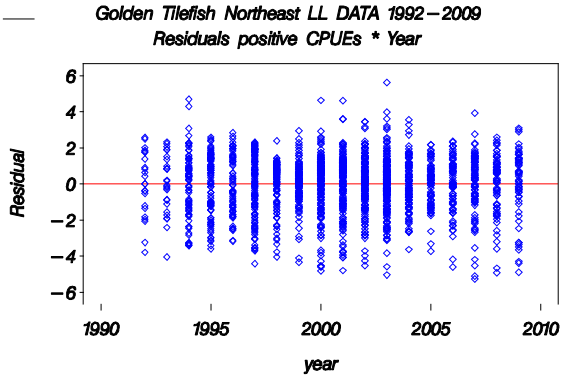
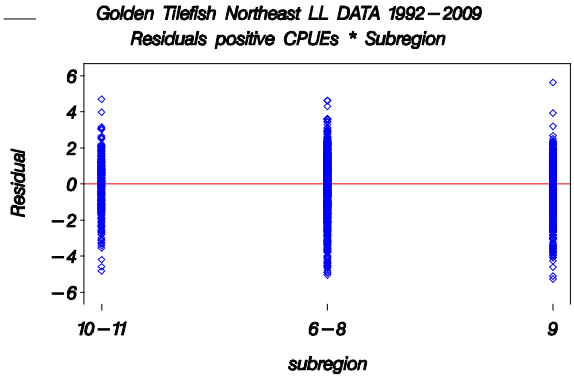


Figure 8. Diagnostic plots for the lognormal component of the northeastern Gulf of Mexico 1992-2009 golden tilefish commercial longline gear model: **A**. the Chi-Square residuals by year; **B**. the Chi-Square residuals by subregion; and **C**. the Chi-Square residuals by days at sea.

A.



B.



C.

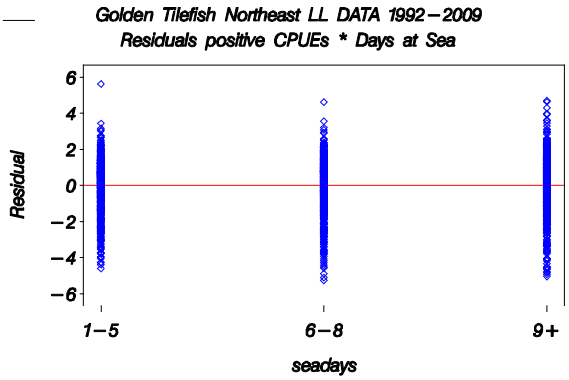
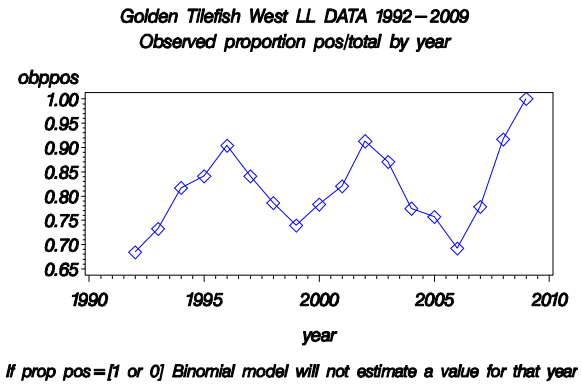


Figure 9. Annual trend in **A.** the proportion of positive trips and **B.** nominal CPUE of the western Gulf of Mexico 1992-2009 golden tilefish commercial longline gear data.

A.



B.

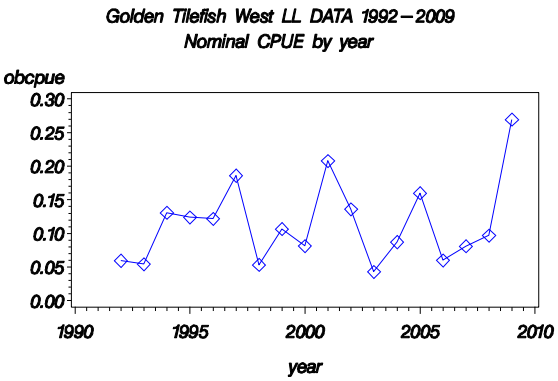
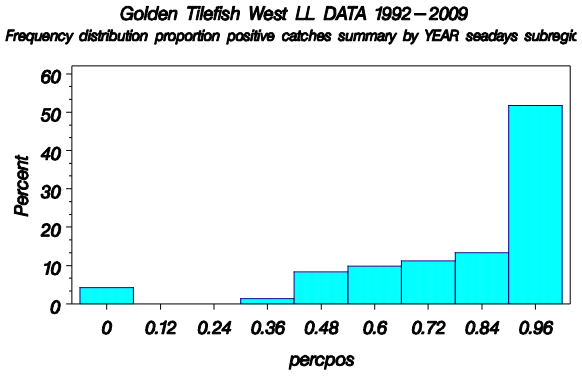
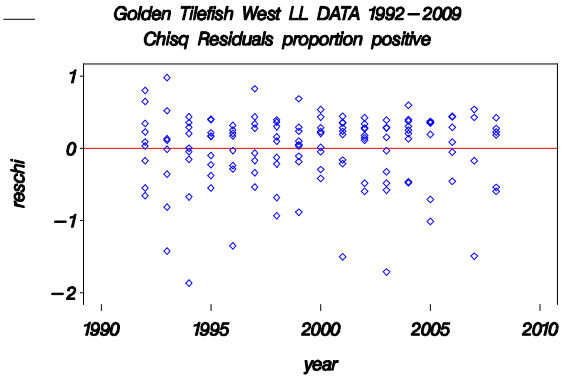


Figure 10. Diagnostic plots for the binomial component of the western Gulf of Mexico 1992-2009 golden tilefish commercial longline gear model: **A**. the frequency distribution of the proportion positive trips; **B**. the Chi-Square residuals by year; **C**. the Chi-Square residuals by subregion; and **D**. the Chi-Square residuals by days at sea. No residuals could be calculated for 2009 because all trips were positive in that year.

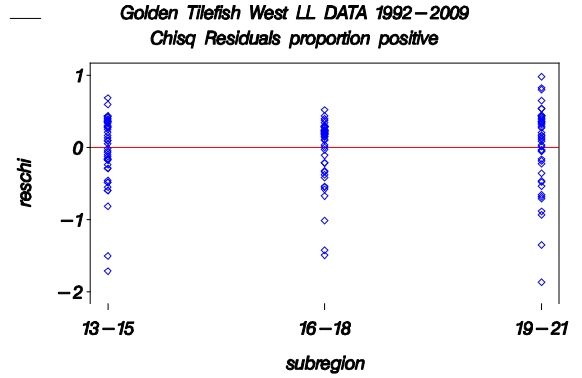
A.



B.



C.



D.

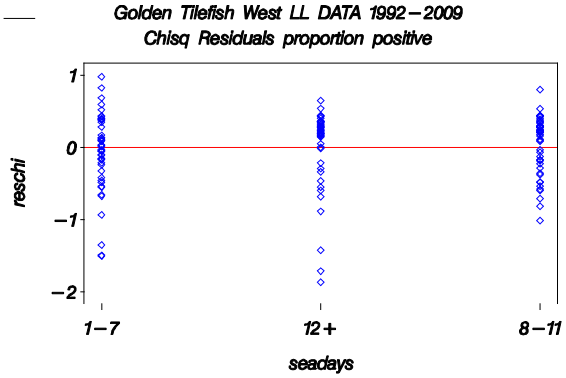


Figure 11. Diagnostic plots for the lognormal component of the western Gulf of Mexico 1992-2009 golden tilefish commercial longline gear model: **A.** the frequency distribution of log(CPUE) on positive trips, **B.** the cumulative normalized residuals (QQ-Plot) from the lognormal model. The red line is the expected normal distribution.

A. **B.**

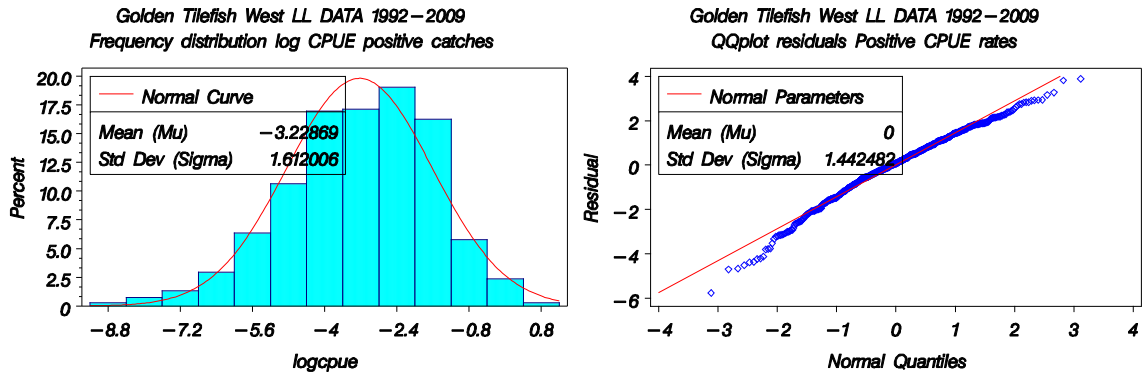
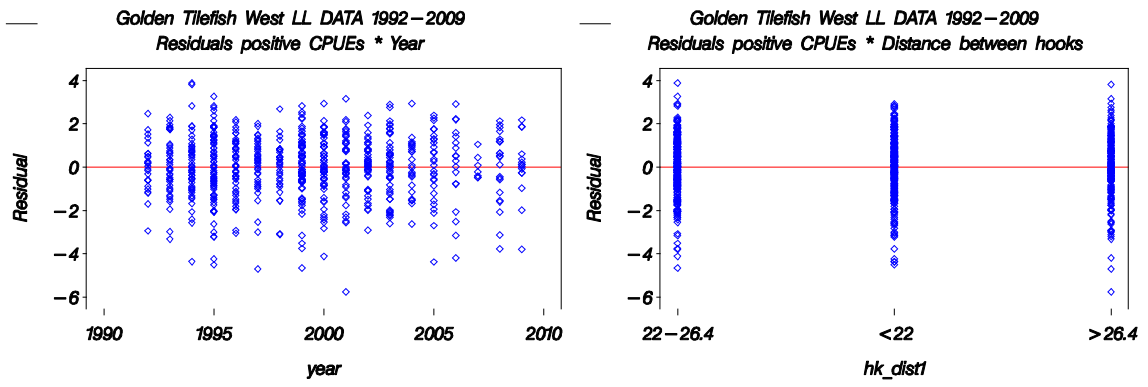


Figure 12. Diagnostic plots for the lognormal component of the western Gulf of Mexico 1992-2009 golden tilefish commercial longline gear model: **A**. the Chi-Square residuals by year; **B**. the Chi-Square residuals by distance between hooks; **C.** the Chi-Square residuals by subregion; and **D**. the Chi-Square residuals by number of crew.

A. **B.**



C. **D.**

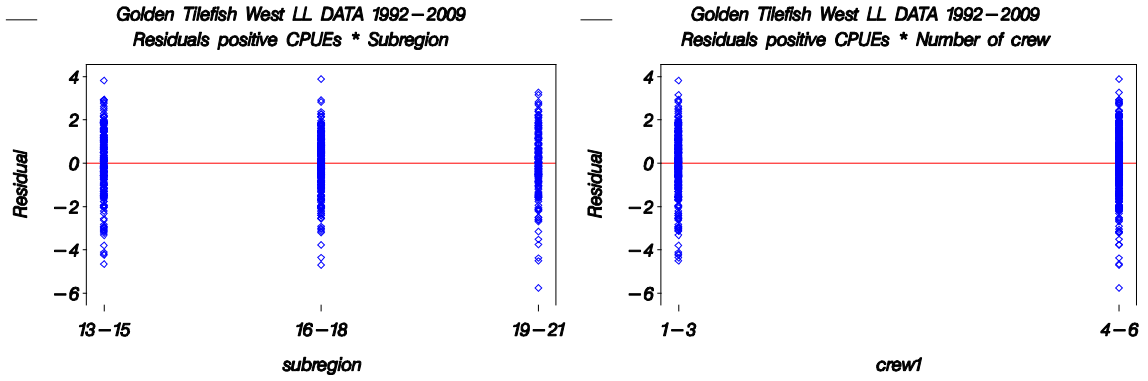
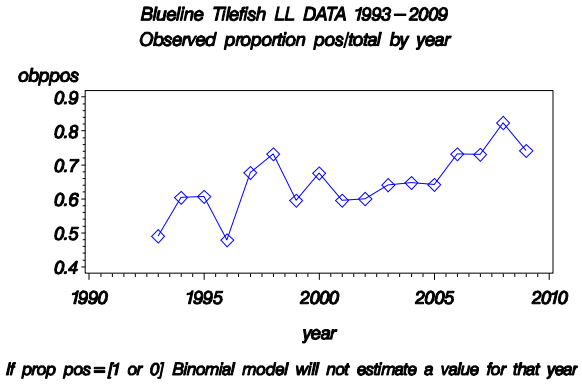


Figure 13. Annual trend in **A.** the proportion of positive trips and **B.** nominal CPUE of the eastern Gulf of Mexico 1993-2009 blueline tilefish commercial longline gear data.

A.



B.

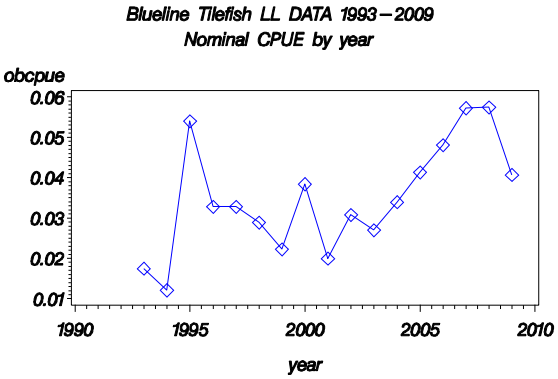
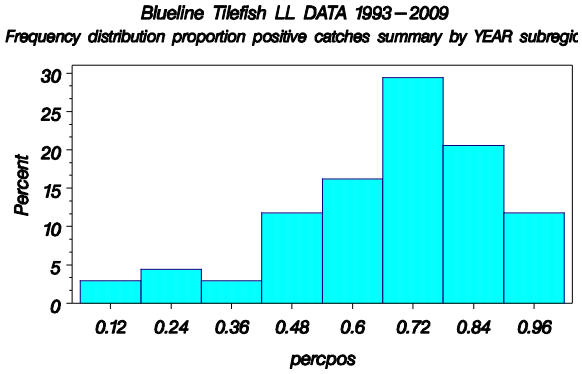
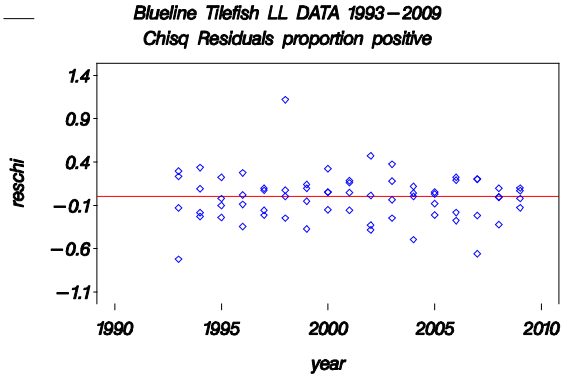


Figure 14. Diagnostic plots for the binomial component of the eastern Gulf of Mexico 1993-2009 blueline tilefish commercial longline gear model: **A**. the frequency distribution of the proportion positive trips; **B**. the Chi-Square residuals by year; and **C**. the Chi-Square residuals by subregion.

A.



B.



C.

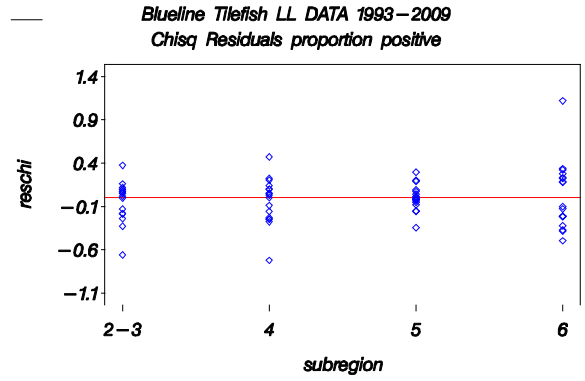


Figure 15. Diagnostic plots for the lognormal component of the eastern Gulf of Mexico 1993-2009 blueline tilefish commercial longline gear model: **A.** the frequency distribution of log(CPUE) on positive trips, **B.** the cumulative normalized residuals (QQ-Plot) from the lognormal model. The red line is the expected normal distribution.

A. **B.**

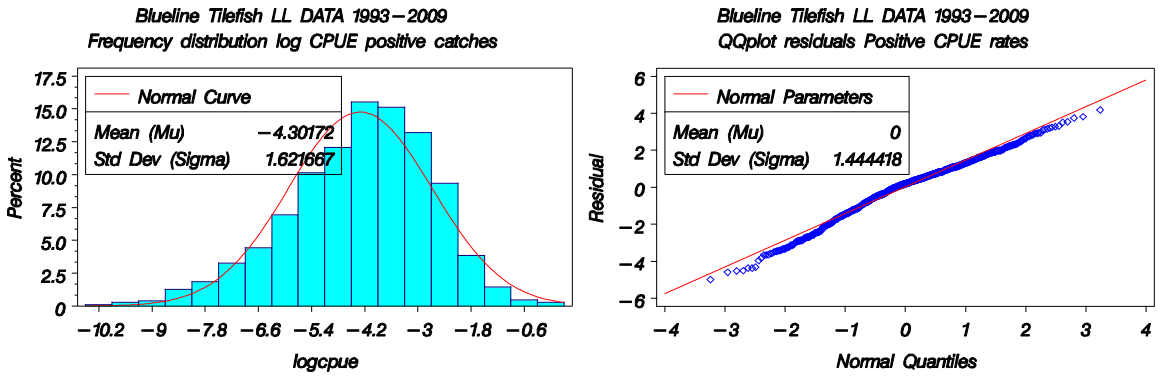
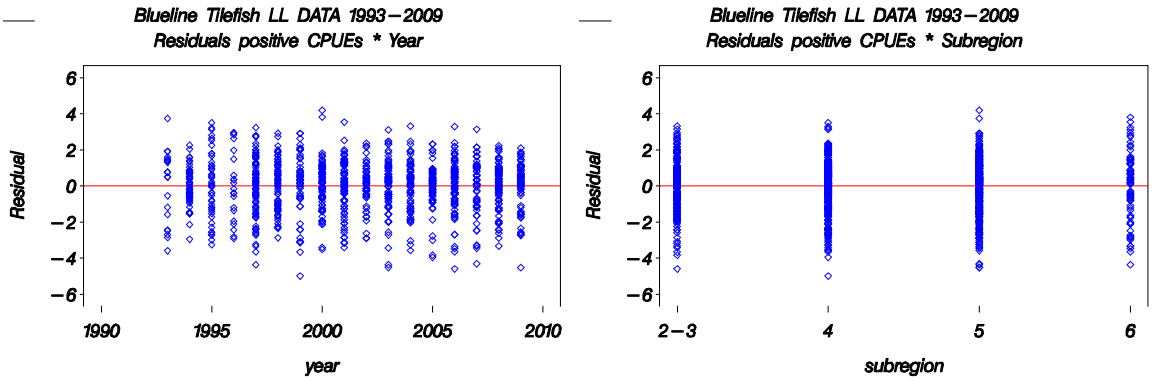


Figure 16. Diagnostic plots for the lognormal component of the eastern Gulf of Mexico 1993-2009 blueline tilefish commercial longline gear model: **A**. the Chi-Square residuals by year; **B**. the Chi-Square residuals by subregion; and **C**. the Chi-Square residuals by distance between hooks.

A. **B.**



C.