Standardized Catch Rates of Blacknose Shark from the Southeast Sink Gillnet Fishery: 2005-2009

John Carlson and Michelle Passerotti
NOAA/National Marine Fisheries Service, Southeast Fisheries Science Center, 3500 Delwood Beach Road, Panama City, FL 32408

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Abstract

A standardization of catch rate series data for blacknose shark from the directed shark sink gillnet fishery was developed based on observer program data collected from 2005-2009. Data were subjected to a Generalized Linear Model (GLM) standardization technique that treats separately the proportion of sets with positive catches (i.e., where at least one shark was caught) assuming a binomial error distribution with a logit link function, and the catch rates of sets with positive catches assuming a lognormal error distribution with a log link function. Year, target and season and meshsize were significant as main effects in the binomial model and lognormal model. The relative abundance index series was stable.

Introduction

Observer coverage of the Florida-Georgia shark gillnet fishery began in 1992, and has since documented the many changes to effort, gear characteristics, and target species the fishery has undergone following the implementation of multiple fisheries regulations (e.g., Passerotti et al. 2010 and references therein). In 2005, the shark gillnet observer program was expanded to include all vessels that have an active directed shark permit and fish with sink gillnet gear. These vessels were not previously subject to observer coverage because they either were targeting non-highly migratory species or were not fishing gillnets in a drift or strike fashion. These vessels were selected for observer coverage in an effort to determine their impact on finetooth shark, *Carcharhinus isodon*, landings and their overall fishing impact on shark resources when the gear is not targeting sharks. In 2006, the National Marine Fisheries Service Southeast Regional Office requested further expansion of the scope of the shark gillnet observer program to include all vessels fishing gillnets regardless of target, and for coverage to be extended to cover the full geographic range of gillnet fishing effort in the southeast United States. This was requested because of the need to monitor (at statistically adequate levels) all gillnet fishing effort to assess risks to right whales and other protected species. Further, in 2007 the regulations implementing the Atlantic Large Whale Take Reduction Plan were amended and included the removal of the mandatory 100% observer coverage for drift gillnet vessels during the right whale calving season but now prohibit all gillnets in an expanded southeast U.S. restricted area that covers an area from Cape Canaveral, FL to the North Carolina/South Carolina border, from November 15 - April 15. The rule does posses limited exemptions, only in waters south of 29 degrees N latitude, for shark strikenet fishing during this same period and for Spanish mackerel gillnet fishing in the months of December and March. Based on these regulations and on current funding levels, the shark gillnet observer program now covers all anchored (sink, stab, set), strike, or drift gillnet fishing by vessels that fish from Florida to the North Carolina year-round. Current protocols for selection of vessels for observer coverage and collection of data are found in Passerotti et al. (2010). Herein, we develop a catch rate series for blacknose shark based on data collected by on-board observers from 2005-2009.

<u>I. Fishery description</u>

Vessel and gear descriptions are provided in detail in Passerotti et al. (2010 and references therein).

<u>Catch rates analysis</u>

A combined data set was developed based from Passerotti et al. (2010 and references therein). Catch rates were standardized in a two-part generalized linear model analysis using the PROC GENMOD procedure in SAS (SAS Inst., Inc.). For the purposes of analysis, several categorical variables were constructed:

-“Year” (5 levels)=2005-2009

- “Area” (4 levels)=location of net set (Figure 1).
South Florida=South of 27°51’ N Latitude
Central Florida=27°51’ N to 30°00’ N Latitude
N. Florida/Georgia=30°00’ N Latitude to 32°00’ N Latitude

North Carolina= North of 32°00' N Latitude
Gulf of Mexico=All sets within the eastern Gulf of Mexico from -88.0 W longitude east.

-'Target" (3 levels)
Shark
Mackerel (Spanish or King Mackerel)
Other Teleost

- "SetBegin" (4 levels)
Dawn=0401-1000 hrs
Day=1001-1600 hrs
Dusk=1601-2200 hrs
Night=2201-0400 hrs

-"Season" (4 levels): corresponds to the level of observer coverage as it pertains to the right whale calving season.
Rightwhale1=Jan-Mar
Nonrightwhale1=Apr-Jun
Nonrightwhale2=Jul-Sep
Rightwhale2=Oct-Dec

-"Meshsize" (3 levels): corresponds to the principal mesh size used in the fishing gear. Small mesh=2"-6" stretched mesh Medium mesh=7"-9" stretched mesh Large mesh=>10" stretched mesh.

The proportion of sets that caught blacknose shark (when at least one blacknose shark was caught) was modeled assuming a binomial distribution with a logit link function. The positive catches were modeled assuming a lognormal distribution with a normal link function. Positive catches were modeled using a dependent variable of the natural logarithm of the number of blacknose shark caught per 10^{-7} net area hours, i.e.:

CPUE=log [(blacknose shark kept+blacknose shark released)/(net length*net depth*soak time/10000000)]

Initially, a null model was run with no factors entered into the model. Models were then fit in a stepwise forward manner adding one independent variable. Each factor was ranked from greatest to least reduction in deviance per degree of freedom when compared to the null model. The factor with the greatest reduction in deviance was then incorporated into the model providing the effect was significant at $p<0.05$ based on a Chi-Square test, and the deviance per degree of freedom was reduced by at least 1% from the less complex model. The process was continued until no factors met the criterion for incorporation into the final model. Regardless of its level of significance, year was kept in all final models. After selecting the set of fixed factors and interactions for each error distribution, all interactions that included the factor year were treated as random interactions (Ortiz and Arocha, 2004). This process converted the basic models from generalized linear models into generalized linear mixed models. The final model determination was evaluated using the Akaike Information Criteria (AIC), and Schwarz's Bayesian Criterion (BIC). Models with smaller AIC and BIC values are preferred to those with larger values. These models were fit using a SAS macro, GLIMMIX (glmm800MaOB.sas: Russ Wolfinger, SAS Institute Inc.) and the MIXED procedure in SAS statistical computer software (PROC GLIMMIX). Relative indices of abundance were calculated as the product of the year effect least square means from the two independent models. The standard error of the combined index was estimated with the delta method (Appendix 1 in Lo et al., 1992).

Results and Discussion

The proportion of positive sets (i.e. at least one blacknose shark was caught) was 19.5%. The stepwise construction of the models is summarized in Table 1. The index statistics can be found in Table 2.

The delta-lognormal abundance index is shown in Figure 2. To allow for visual comparison with the nominal values, both series were scaled to the maximum of their respective index. The average size of blacknose sharks caught by year is reported in Table 3. Table 4 provides a table of the frequency of observations by factor and level. Diagnostic plots assessing the fit of the models were deemed acceptable (Figure 3).

References

Lo, N.C., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49:2515:2526.

Ortiz, M., and F. Arocha. 2004. Alternative error distribution models for standardization of catch rates of non-target species from a pelagic longline fishery: billfish species in the Venezuelan tuna longline fishery. Fisheries Research 70, 275–294.

Passerotti, M.S., J.K. Carlson, and S.J.B. Gulak. 2010. Catch and Bycatch in U.S. Southeast Gillnet Fisheries, 2009. NOAA Technical Memorandum NMFS-SEFSC-600. 20 p.

Acknowledgements

We thank all observers for collecting data from this fishery since the initiation of the program.

Table 1. Analysis of deviance of explanatory variables for the binomial and lognormal generalized linear formulations of the proportion of positive and positive catches for blacknose shark.

Proportion positive-Binomial error distribution							
FACTOR	**DF**	**DEVIANCE**	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	576	579.1241	1.005				
YEAR	572	501.5486	0.877	12.790	12.790	77.58	<.0001
YEAR+							
TARGET	570	408.6029	0.717	28.702	15.912	92.95	<.0001
SEASON	569	425.5891	0.748	25.608		75.96	<.0001
MESHSIZE	570	458.9524	0.805	19.916		42.6	<.0001
AREA	568	472.2257	0.831	17.310		29.32	<.0001
SETBEGIN	569	489.0512	0.859	14.514		12.5	0.0059
YEAR+TARGET							
SEASON	567	353.949	0.624	37.912	9.210	54.65	<.0001
AREA	566	393.0058	0.694	30.939		15.6	0.0036
MESHSIZE	568	406.353	0.715	28.845		2.25	0.3246
YEAR+TARGET+SEASON							
AREA	563	346.969	0.616	38.704	0.792	6.98	0.137
MIXED MODEL	**AIC**	**BIC**	**(-2) LOGLIKELIHOOD**				
YEAR+TARGET+SEASON	155.6	156.9	153.6				
YEAR+TARGET+SEASON YEAR*TARGET	**155.6**	**156.3**	**153.6**				
YEAR+TARGET+SEASON YEAR*SEASON	155.6	156.5	153.6				

Positive catches-Lognormal error distribution							
FACTOR	**DF**	**DEVIANCE**	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	115	282.1902	2.454				
YEAR	111	217.4668	1.959	20.159	20.159	30.22	<.0001
YEAR+							
MESHSIZE	109	189.7572	1.741	29.054	8.895	15.81	0.0004
SEASON	108	191.2835	1.771	27.821		14.88	0.0019
AREA	107	195.94	1.831	25.373		12.09	0.0167
TARGET	109	209.975	1.926	21.495		4.07	0.1309
SETBEGIN	108	209.05	1.936	21.117		4.58	0.2054
YEAR+MESHSIZE							
AREA	105	161.5664	1.539	37.293		18.66	0.0009
SEASON	106	173.0028	1.632	33.488		10.72	0.0133
YEAR+MESHSIZE+AREA							
SEASON	102	145.0631	1.422	42.042	4.749	12.5	0.0059
MIXED MODEL	AIC	BIC	(-2) LOGLIKELIHOOD				
YEAR+MESHSIZE+AREA+SEASON	370.7	373.4	368.7				
YEAR+MESHSIZE+AREA+SEASON YEAR*MESHSIZE	368.3	368.9	364.3				
YEAR+MESHSIZE+AREA+SEASON YEAR*SEASON	370.7	371.3	368.7				
YEAR+MESHSIZE+AREA+SEASON YEAR*AREA	**367.7**	**369.2**	**363.7**				

Table 2. The absolute standardized and nominal index of abundance for blacknose shark with the associated coefficients of variation (CV) and number of sets observed (N).

Year	Standardized index	CV	N	Nominal index	CV
2005	241.644	0.43	73	495.351	2.63
2006	86.111	0.46	141	87.719	5.58
2007	1665.538	0.30	79	1687.760	2.34
2008	196.587	0.61	119	47.190	5.22
2009	28.285	0.52	171	48.356	7.12

Table 3. Mean size of blacknose shark from the sink gillnet fishery.

Year	Mean	Standard Deviation	N
2005	100.9	8.37	11
2006	64.5	20.51	2
2007	99.3	8.88	49
2008	90.7	6.50	9
2009	87.6	6.69	74

Table 4. Frequency of observations by factor and level used in the development of the standardized catch rate series.

FACTOR	LEVEL	FREQUENCY OF TOTAL
YEAR	2005	12.5
	2006	24.2
	2007	13.6
	2008	20.4
	2009	29.3
AREA	Central Florida	50.4
	Georgia	19.9
	Gulf of Mexico	3.9
	North Carolina	16.3
	South Florida	9.4
TARGET	Mackerel	40.7
	Other	33.6
	Shark	25.7
SETBEGIN	Dawn	42.1
	Day	42.8
	Dusk	13.7
	Night	1.4
SEASON	Rightwhale1=Jan	36.4
	Nonrightwhale1=Apr	16.8
	Nonrightwhale2=Jul	26.4
	Rightwhale2=Oct	20.4
MESHSIZE	Large	2.4
	Medium	12.3
	Small	85.2

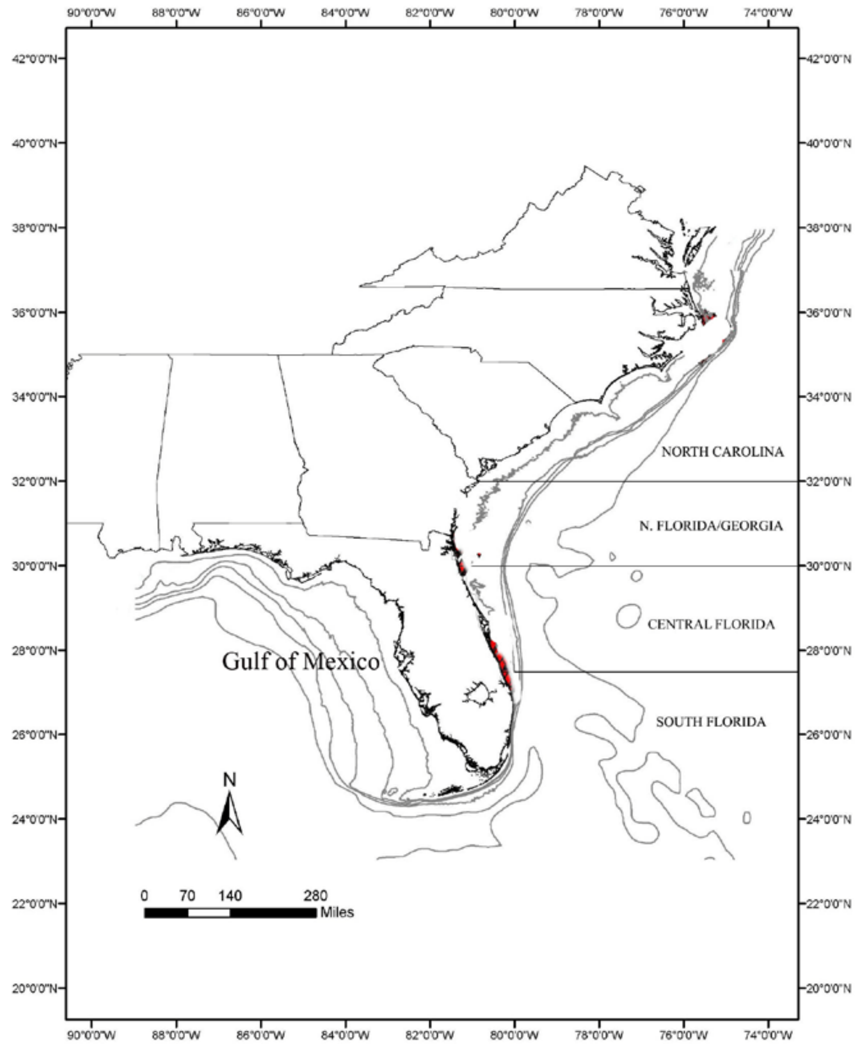


Figure 1. Distribution of fishing effort in the southeast US sink gillnet fishery 2005-2009. Fishing areas defined for GLM analysis are: South Florida, Central Florida, North Florida/Georgia, North Carolina and Gulf of Mexico. An individual plot by year and in some locations was not possible because of vessel confidentiality.

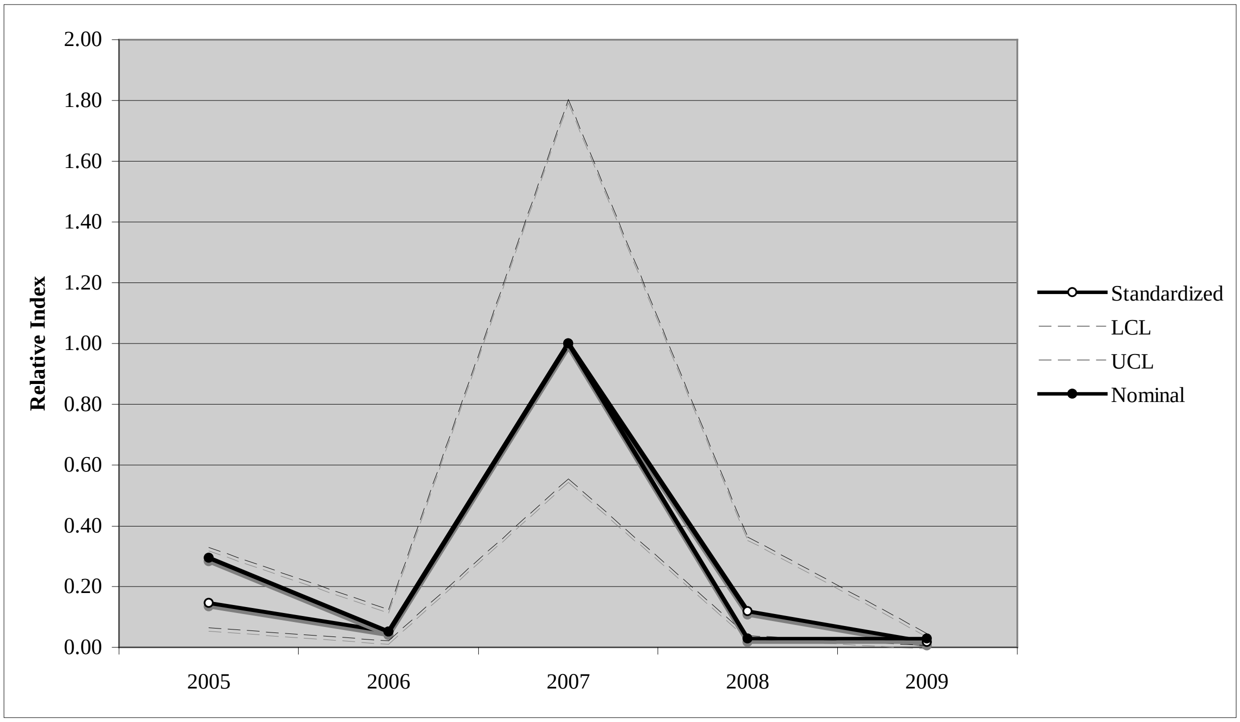
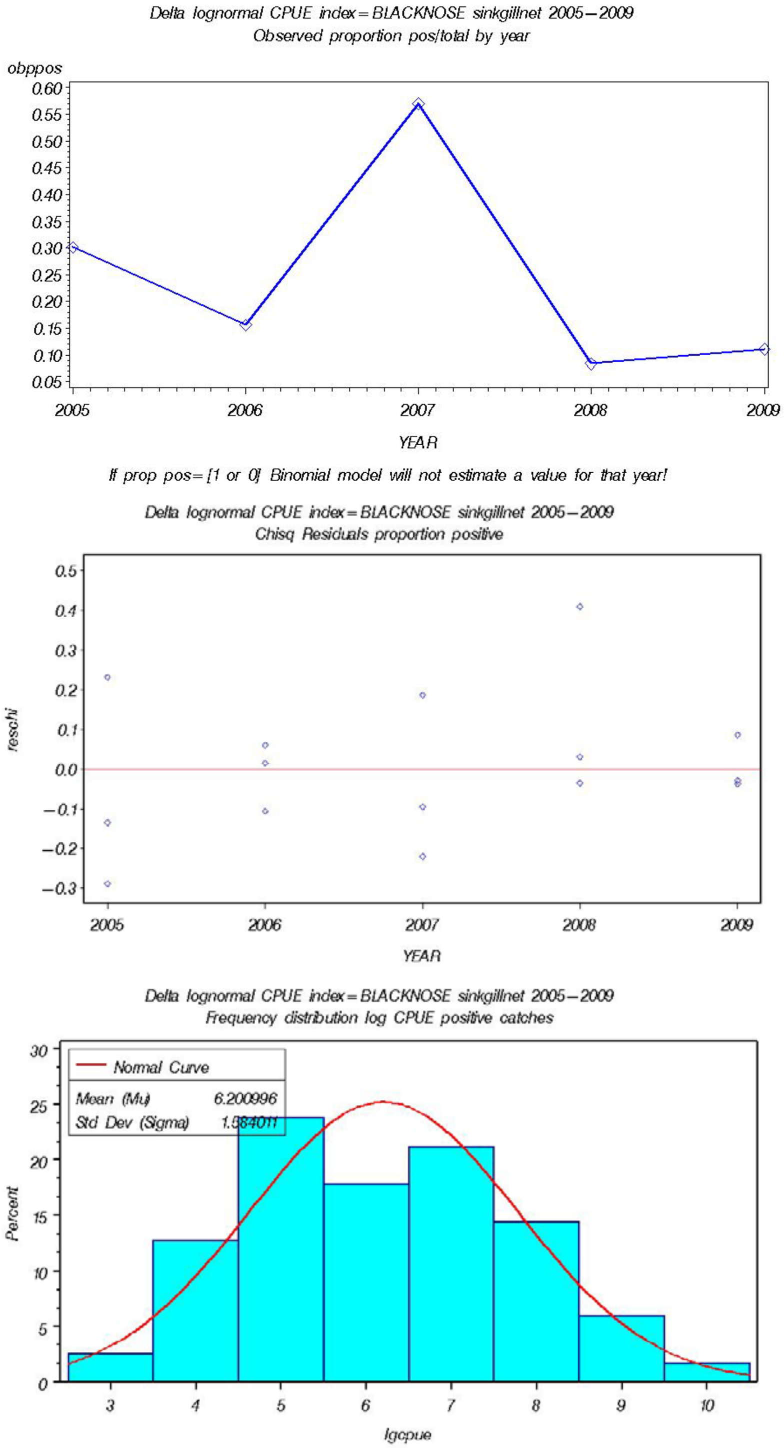
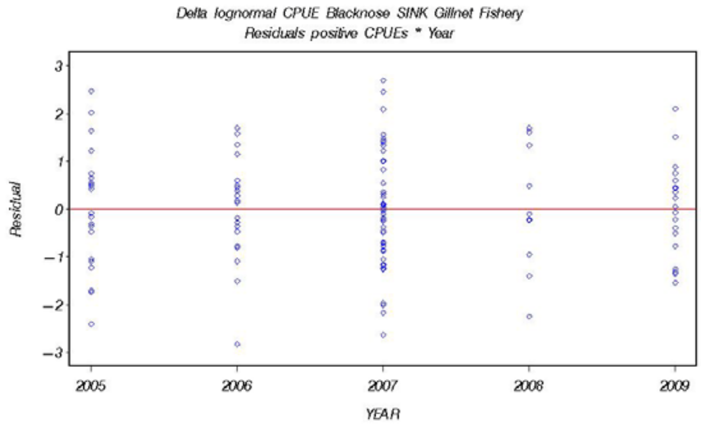
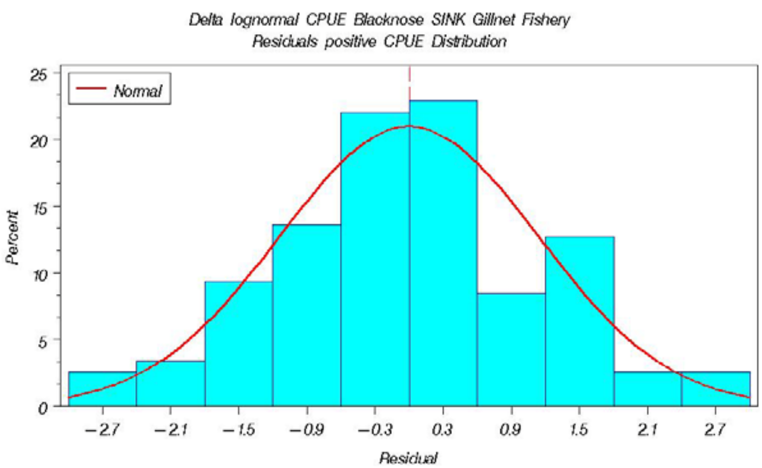


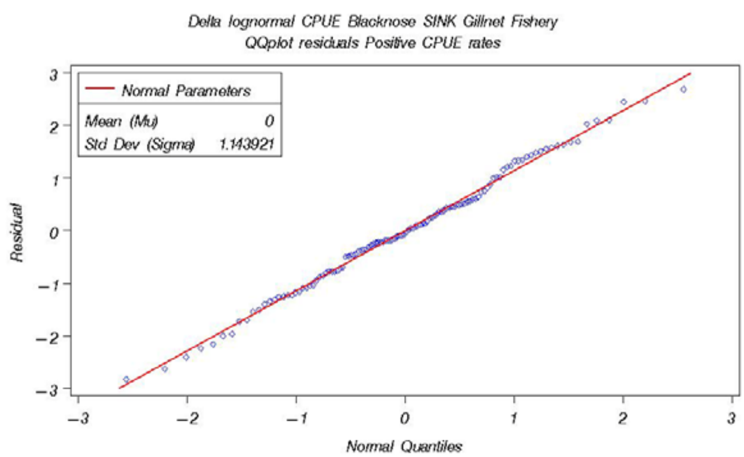
Figure 2. Nominal and standardized indices of abundance for blacknose shark. The dashed lines are the 95% confidence limits for the standardized index. Each index has been divided by the maximum of the index.

Figure 3. Diagnostic plots of the model outputs for blacknose shark.




Delta lognormal CPUE Blacknose SINK Gillnet Fishery
Residuals positive CPUEs * Year
Residual
YEAR
2005
2006
2007
2008
2009


Delta lognormal CPUE Blacknose SINK Gillnet Fishery
Residuals positive CPUE Distribution
Normal
Percent
Residual


Delta lognormal CPUE Blacknose SINK Gillnet Fishery
QQplot residuals Positive CPUE rates
Normal Parameters
Mean (Mu) 0
Std Dev (Sigma) 1.143921
Residual
Normal Quantiles

ADDENDUM TO SEDAR21-DW-04

(Standardized Catch Rates of Blacknose Shark from the Southeast Sink Gillnet Fishery: 2005-2009**)**

Introduction

Based on discussion at the 2010 SEDAR 21, the stock of blacknose shark has been split to a NW Atlantic Ocean and Gulf of Mexico population. The present addendum to document **SEDAR 21-DW-04** revises standardized catch rates and provides a new catch rate series for blacknose shark for the NW Atlantic Ocean stock only. Samples in the Gulf of Mexico were insufficient to provide a useful series. All analysis followed standardization procedures previously outlined in **SEDAR21-DW-04.** New and revised estimates are listed below:

Table 1. Final mixed model selection. The final model determination was evaluated using the Akaike Information Criteria (AIC), and Schwarz's Bayesian Criterion (BIC).

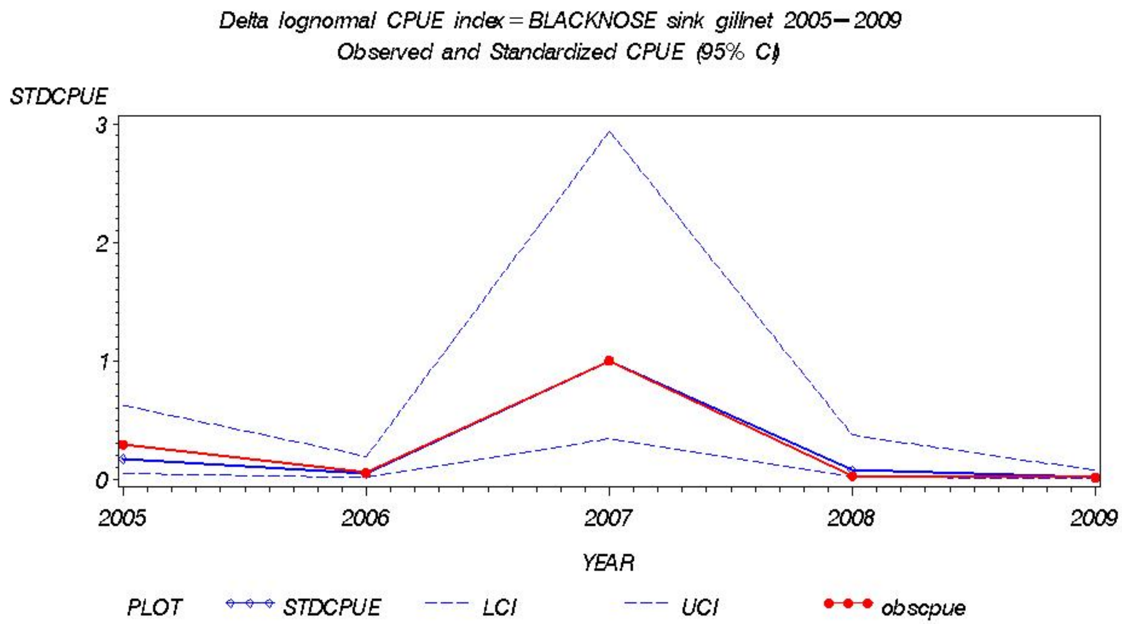
Proportion positive-Binomial error distribution					**Positive catches-Lognormal error distribution**			
MIXED MODEL	AIC	BIC	(-2) LOGLIKELIHOOD		MIXED MODEL	AIC	BIC	(-2) LOGLIKELIHOOD
YEAR+TARGET+SEASON	145.6	146.9	143.6		YEAR+MESHSIZE+AREA+SEASON	356.4	359.1	354.4
YEAR+TARGET+SEASON YEAR*TARGET	**145.6**	**146.3**	**143.6**		YEAR+MESHSIZE+AREA+SEASON YEAR*MESHSIZE	353.8	354.2	349.8
YEAR+TARGET+SEASON YEAR*SEASON	145.6	146.5	143.6		YEAR+MESHSIZE+AREA+SEASON YEAR*AREA	356.4	356.9	354.4
					YEAR+MESHSIZE+AREA+SEASON YEAR*SEASON	**352.9**	**354.3**	**348.9**

Table 2. The absolute standardized and nominal index of abundance for blacknose shark with the associated coefficients of variation (CV) and number of sets observed (N).

Year	Standardized index	CV	N	Nominal index	CV
2005	216.32	0.72	73	495.35	2.63
2006	60.53	0.78	141	87.72	5.58

2007	1262.50	0.58	79	1687.76	2.34
2008	98.26	0.91	119	47.19	5.22
2009	20.23	0.88	148	23.52	4.68

Figure 1. Nominal and standardized indices of abundance for blacknose shark. The dashed lines are the 95% confidence limits for the standardized index. Each index has been divided by the maximum of the index.


Delta lognormal CPUE index = BLACKNOSE sink gillnet 2005−2009
Observed and Standardized CPUE (95% CI)
STDCPUE
3
2
1
0
2005
2006
2007
2008
2009
YEAR
PLOT
STDCPUE
LCI
UCI
obscpue