Standardized Catch Rates of Blacknose Shark from the Southeast Shark Drift Gillnet Fishery: 1993-2009

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

SEDAR21-DW-03

Abstract

A standardization of catch rate series data from the directed shark drift gillnet fishery was developed based on observer programs from 1993-1995 and 1998-2009. Depending on season and area, small coastal species, including blacknose shark, are targeted and harvested. The final model assumed a binomial distribution for the proportion of positive trips and a lognormal distribution for positive catch rates. Year and area were significant as a main effect in the binomial model and lognormal model. The relative abundance index shows a slight increase in abundance since 1993.

Introduction

The shark drift gillnet fishery developed off the east coast of Florida and Georgia in the late 1980's (Trent el. al 1997). 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). Most recently, the directed large coastal shark (LCS) gillnet fishery has been significantly reduced since the implementation of Amendment 2 to the Consolidated Atlantic Highly Migratory Species Fishery Management Plan (NMFS 2007). The 33-head LCS trip limit implemented by Amendment 2 has essentially ended the strike net fishery and limited the number of fishers targeting LCS with drift gillnet gear. This regulation has also limited the small coastal shark gillnet fishery. Currently, there are a total of 222 directed and 276 incidental shark permits issued to fishers in the US Atlantic and Gulf of Mexico, of which only a small portion use gillnet gear. Many gillnet fishers have now begun targeting coastal teleost species with varying types of gillnet gear. As such, the southeast gillnet observer program currently covers all anchored (sink, stab, set), strike, or drift gillnet fishing by vessels that fish from Florida to North Carolina and in the Gulf of Mexico 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 1993-1995 and 1998-2009.

<u>I. Fishery description</u>

Vessels, fishing gear, and fishing techniques have been previously described in Trent et al. (1997). Generally, shark driftnet vessels operate between 4.8 and 14.4 km from shore in areas north of Key West, FL (~24° 37-24° 58' N) and between West Palm Beach, FL (~26° 46'N) and Altamaha Sound, GA (~31° 45' N) (Figure 1). Vessels fish gillnets (both multi and monofilament) ranging in length from 547.2-2,736 m; depths from 9.1-13.7 m and stretched mesh sizes from 12.7-25.4 cm (Passerotti et al. 2010 and references therein). Nets are normally set in a straight line off the stern at night, allowed to drift at the surface for a period of time and then hauled onto the vessel when the catch is adequate. The number of drift gillnet vessels has decreased from about 12 in 1990 to about 3-6, depending on the market value of sharks and the level of activity in other fisheries.

Information on this fishery was collected using on-board NMFS-approved contract observers. The observer normally left port with the vessel between 1500-1700 hrs; depending on distance to the fishing grounds. Trips are normally 1-3 days in duration. For each set and haul of the net observers recorded: beginning and ending times of setting and hauling; estimated length of net set; latitude and longitude coordinates; and water depth. During haul back, the observer remained about 3-8 m forward of the net reel in an unobstructed view and recorded species, numbers and estimated lengths (±30 cm) of sharks and other species caught as they were suspended in the net just after passing over the power roller.

<u>Catch rates analysis</u>

A combined data set was developed based on observer programs from Trent el al. (1997) and 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” (15 levels)=1993-1995, 1998-2009

- “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
Georgia-North Carolina=North of 30°00’ N Latitude
Gulf of Mexico=All sets within the eastern Gulf of Mexico from -88.0 W longitude east.

- “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=4”-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 61.9%. The stepwise construction of the models is summarized in Table 1. The index statistics can be found in Table 2. Average size of sharks captured is in Table 3.

The delta-lognormal abundance index is shown in Figure 2. To allow for visual comparison with the nominal values, both series were scaled to their respective means. 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

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Trent, L., D.E. Parshley and J.K. Carlson. 1997. Catch and bycatch in the shark drift gillnet fishery off Georgia and east Florida. Mar. Fish. Rev. 59(1):19-28.

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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. Model is bold is the final selected model.

Proportion positive-Binomial error distribution							
FACTOR	**DF**	**DEVIANCE**	**DEVIANCE/DF**	**%DIFF**	**DELTA%**	**CHISQUARE**	**PR>CHI**
NULL	441	587.0718	1.331				
YEAR	427	531.8962	1.246	6.428	6.428	55.18	<.0001
YEAR+							
AREA	424	469.7743	1.108	16.772	10.344	62.12	<.0001
SEASON	424	505.725	1.193	10.403		26.17	<.0001
MESHSIZE	425	520.9885	1.226	7.915		10.91	0.0043
SETBEGIN	424	529.7142	1.249	6.152		2.18	0.5355
YEAR+AREA							
SEASON	421	464.3974	1.103	17.138		5.38	0.1462
MESHSIZE	422	469.337	1.112	16.455		0.44	0.8034
MIXED MODEL	AIC	BIC	(-2) LOGLIKELIHOOD				
YEAR+AREA	**66.1**	**66.9**	**64.1**				
YEAR+ AREA YEAR*AREA	66.5	69.6	62.5				

Positive catches-Lognormal error distribution							
FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	CHISQUARE	PR>CHI
NULL	273	1449.1751	5.308				
YEAR	260	1231.3688	4.736	10.781	10.781	44.63	<.0001
YEAR+							
AREA	257	685.8703	2.669	49.725	38.944	160.34	<.0001
MESHSIZE	258	999.8143	3.875	26.997		57.08	<.0001
SEASON	257	1201.2036	4.674	11.951		6.8	0.0787
SETBEGIN	257	1215.4133	4.729	10.909		3.57	0.3113
YEAR+AREA							
MESHSIZE	255	674.544	2.645	50.168	0.442	4.56	0.1022
MIXED MODEL	AIC	BIC	(-2) LOGLIKELIHOOD				
YEAR+AREA	1029.0	1032.6	1027.0				
YEAR+AREA YEAR*AREA	**983.6**	**986.5**	**979.6**				

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
1993	16.20	1.46	5	464.67	1.28
1994	114.67	0.78	39	345.84	1.51
1995	48.91	1.16	7	237.27	1.23
1996					
1997					
1998	28.51	0.99	9	21.59	1.43
1999	54.21	0.65	50	122.88	1.83
2000	108.34	0.67	53	2421.50	2.71
2001	56.39	0.61	91	101.92	3.62
2002	166.10	0.58	70	1791.94	4.19
2003	59.95	0.69	24	1802.32	3.92
2004	43.81	0.67	32	126.50	1.90
2005	239.03	0.75	31	128.59	2.38
2006	14.49	1.04	4	8.95	0.91
2007	43.78	1.04	4	32.14	1.27
2008			16	0.00	0.00
2009	83.61	1.05	7	1473.23	0.94

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

Year	Mean	Standard Deviation	N
2001	101	7.5	10
2002	102	6.0	10
2003	105	8.9	10
2004	103	9.2	18
2005	54.5	3.5	2
2006			
2007			
2008			
2009	85.5	3.7	4

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	1993	1.1
	1994	8.7
	1995	1.6
	1996	
	1997	
	1998	2.0
	1999	11.0
	2000	12.0
	2001	20.4
	2002	15.9
	2003	5.4
	2004	7.3
	2005	7.0
	2006	0.9
	2007	0.9
	2008	3.6
	2009	1.6
AREA	Central Florida	24.7
	Georgia-North Carolina	24.9
	Gulf of Mexico	10.4
	South Florida	40.0
SETBEGIN	Dawn	5.0
	Day	2.7
	Dusk	61.8
	Night	30.5
SEASON	Rightwhale1=Jan	24.7
	Nonrightwhale1=Apr	31.9
	Nonrightwhale2=Jul	41.9
	Rightwhale2=Oct	1.6
MESHSIZE	Large	20.6
	Medium	36.4
	Small	43.0

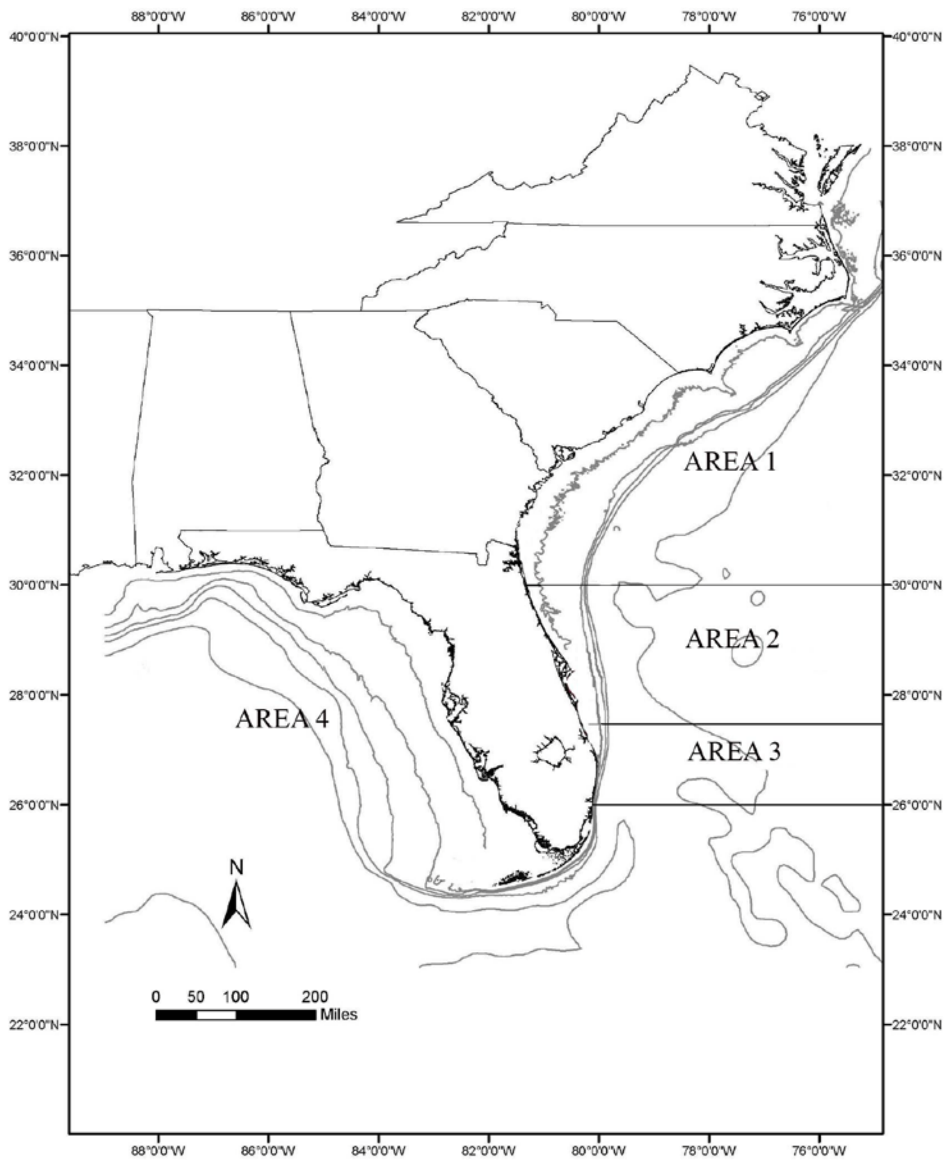


Figure 1. Distribution of fishing effort in the directed shark drift gillnet fishery 1993-2009. Fishing areas defined for GLM analysis are; area 1: Georgia to North Carolina; area 2: Central Florida; area 3: South Florida, area 4: eastern Gulf of Mexico. Individual plots by year and in some locations were not possible because of vessel confidentiality.

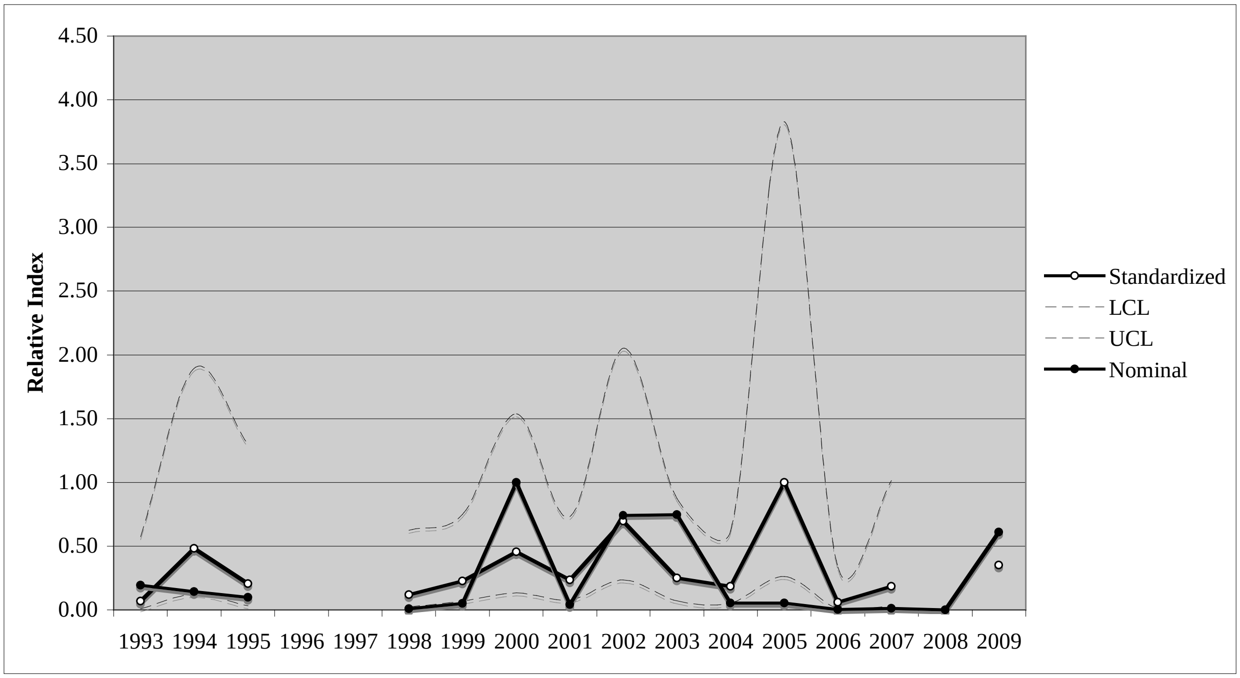
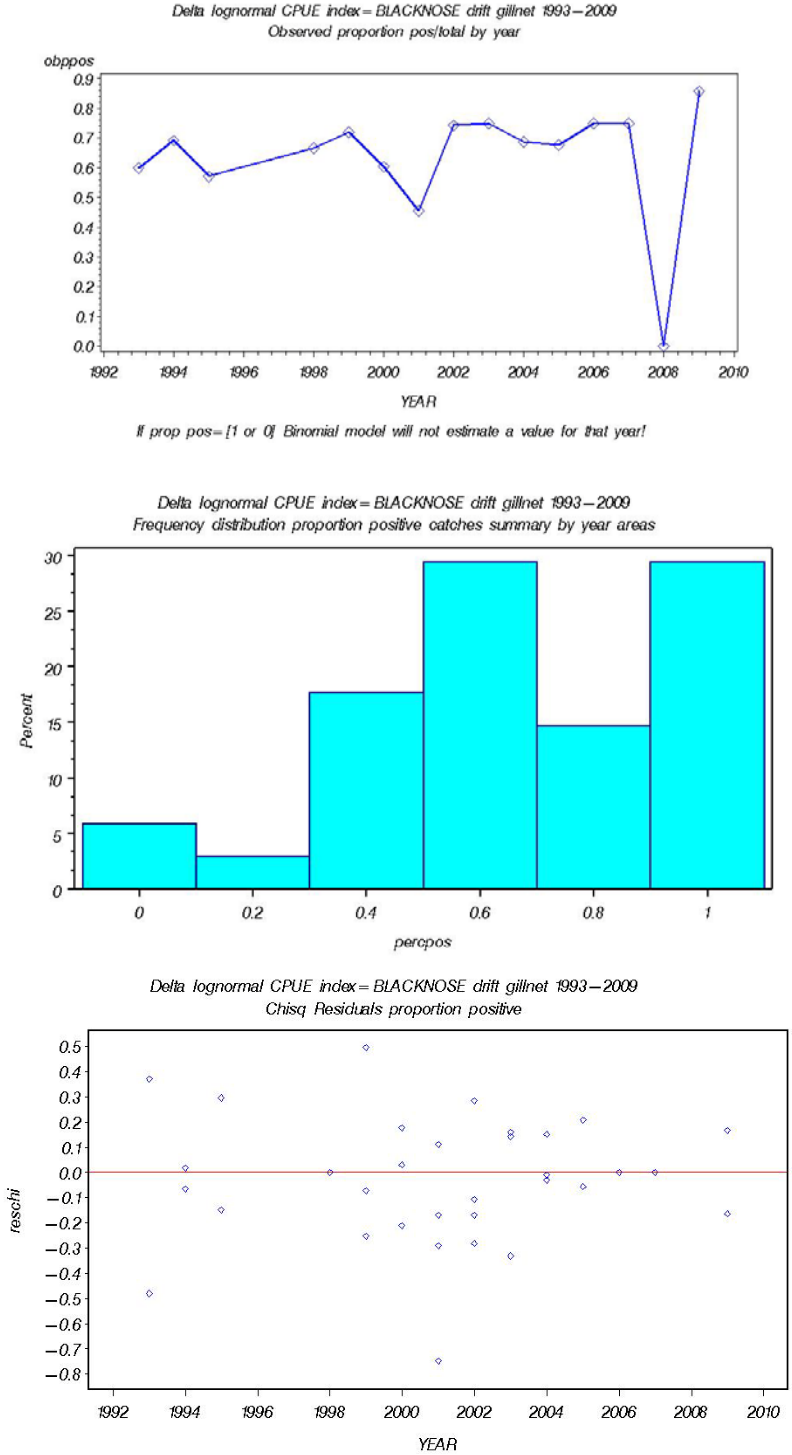
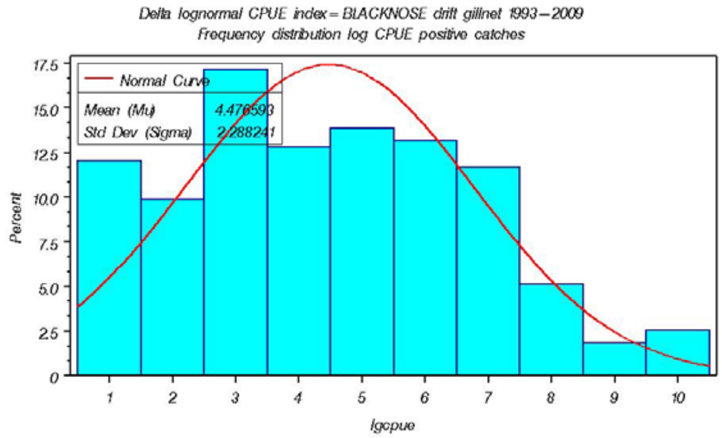
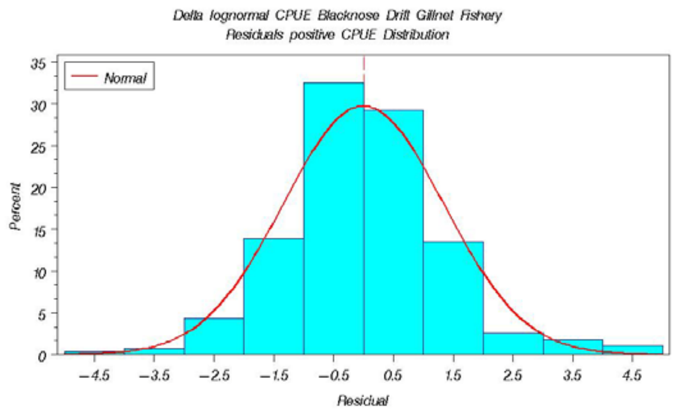


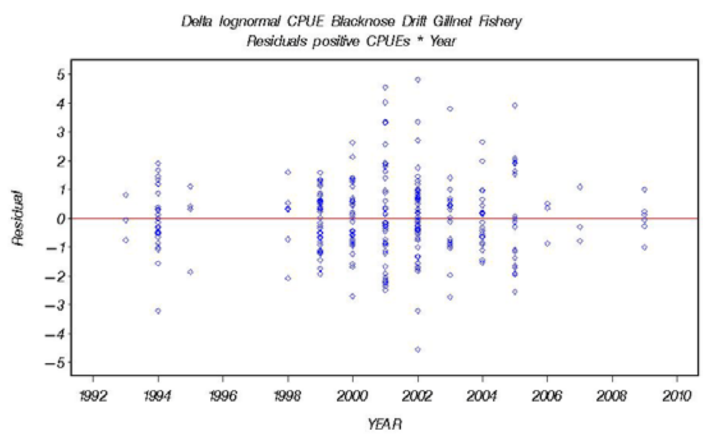
Figure 2. Nominal and standardized indices of abundance for blacknose shark. The dashed lines are the 95% confidence limits for the standardized index. Each index has been divided by the maximum of the index.

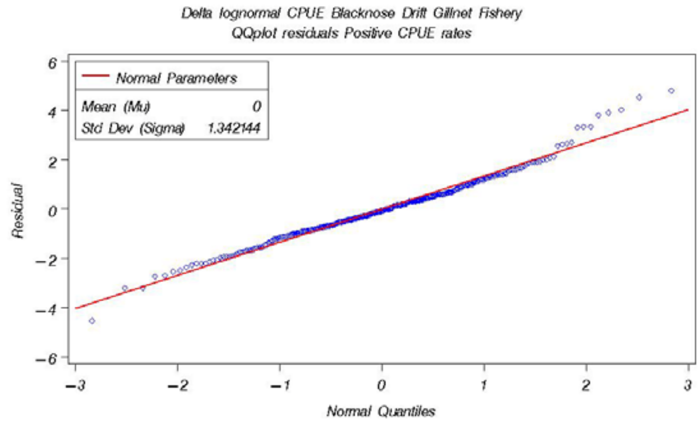
Figure 3. Diagnostic plots of the frequency distribution of residuals, quantile-quantile plots, and distribution of residuals by year from the lognormal model for blacknose shark.




Delta lognormal CPUE index= BLACKNOSE drift gillnet 1993-2009
Frequency distribution log CPUE positive catches
Normal Curve
Mean (Mu) 4.476593
Std Dev (Sigma) 2.288241
Percent
lgcpue


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


Delta lognormal CPUE Blacknose Drift Gillnet Fishery
Residuals positive CPUEs * Year
Residual
YEAR


Delta lognormal CPUE Blacknose Drift Gillnet Fishery
QQplot residuals Positive CPUE rates
Normal Parameters
Mean (Mu) 0
Std Dev (Sigma) 1.342144
Residual
Normal Quantiles
6
4
2
0
−2
−4
−6
−3
−2
−1
0
1
2
3

ADDENDUM TO SEDAR21-DW-03
(Standardized Catch Rates of Blacknose Shark from the Southeast Shark Drift Gillnet Fishery: 1993-2009**)**

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 **SEDAR21-DW-03** 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-03. However, with the reduction in samples per cell the convergence of the binomial model was questionable. The final model was run but the validity of the model fit is questionable.**

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	**-18E307**	**-18E307**	**-18E307**		**YEAR+AREA**	**893.6**	**897.1**	**891.6**

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
1993	102.32	0.74	5	470.42	1.28
1994	242.69	0.31	39	344.00	1.51
1995	101.61	0.67	7	230.44	1.23
1996	-				
1997	-				
1998	59.98	0.59	9	21.17	1.43
1999	78.31	0.27	50	121.56	1.83
2000	355.07	0.31	44	2694.05	2.71
2001	151.28	0.28	78	103.00	3.62
2002	115.41	0.28	48	703.32	4.19
2003	117.90	0.36	24	1660.05	3.92
2004	68.61	0.33	32	126.25	1.90
2005	317.74	0.35	31	125.50	2.38
2006	29.11	0.75	4	8.85	0.91

2007	88.94	0.75	4	31.72	1.27
2008	-		16	0.00	0.00
2009	-		5	1999.69	0.94

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.