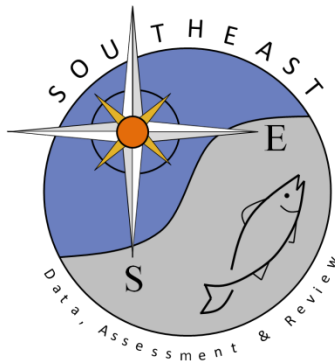


Relative abundance of *Mustelus spp.* in the Gulf of Mexico based on
observer data collected in the reefish bottom longline fishery

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**Relative abundance of *Mustelus spp.* in the Gulf of Mexico based on observer data
collected in the reefish bottom longline fishery**

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Introduction

This reefish fishery in the Gulf of Mexico consists of approximately 890 federally permitted vessels. Primary gears used in this fishery include bottom longline, vertical line (bandit or handline) and more recently buoy gear. Although all reef fish species are retained, the predominant target species are groupers, *Epinephelus* spp., and snappers, *Lutjanus* spp. Details of the fishery and its operations can be found in Scott-Denton et al. (2011). Of the approximately 890 permitted vessels about 130 report fishing with bottom longline gear opposed to bandit or handline for the majority of their trips.

Data collected by at-sea observers of this fishery began in 2005 by the NMFS-Panama City Laboratory. While the focus of the Panama City Laboratory observer program was on shark directed bottom longline trips, observers also boarded bottom longline fishing trips that targeted grouper, snapper, and tilefish because of the overlap in vessels carrying dual permits (shark and reefish). The NMFS-Galveston Laboratory also began observer coverage of this fishery in 2006 as part of the observer program to monitor the reefish fishery in the Gulf of Mexico. Both programs have continued observations of this fishery since 2006. During some hauls, *Mustelus* spp., are caught as bycatch and retained and landed. Herein we determine a relative abundance index for *Mustelus* spp. for the bottom longline portion of the reefish fishery in the Gulf of Mexico using combined data from both the Panama City and Galveston Laboratory observer programs.

Methods

Vessel selection

NMFS observers were placed on bottom longline vessel targeting reeffish throughout the Gulf of Mexico based season, gear, and region. Observer coverage is based on proportional sampling effort, based on coastal logbook data, among seasons and gears in the eastern and western Gulf of Mexico. Further details are available in Scott-Denton et al. (2011) and Hale et al. (2012).

Selection letters requiring observer coverage were issued to permit holders via U.S. certified mail approximately one month prior to the upcoming fishing season. Once the permit holder received the selection letter, he or she was required to contact the observer coordinator and indicate intent to fish during the upcoming fishing season. If the permit holder intended to fish, the observer coordinator deployed an observer to the port of departure (Hale et al. 2007; Scott-Denton et al. 2011).

Observer Protocol

For consistency among longline observer programs throughout the Southeast Fisheries Science Center, observers complete three data forms: Longline Gear Characteristic Log, Longline Haul Log, and Individual Animal Log. The Longline Gear Characteristic Log is used to record the type and length of the mainline used, number and length of gangions, and make and model of hooks used. The Longline Haul Log is used to record the length, location, and time duration for each set and haulback, as well as environmental information and the type(s) of bait used. The Individual Animal Log records all species caught, condition on capture (e.g. alive, dead, damaged, or unknown)

when brought to the vessel, and the final condition on release (e.g. kept, released, finned, etc.). When an animal is brought aboard the vessel, the observer records species, condition on capture, sex (when possible), and length.

Catch rate analysis

A combined data set was developed based on observer programs from Hale et al. (2012) and Scott-Denton et al. (2011). Only sets that reported targeting reefish with bottom longline gear were included in the analysis. 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 assumed to influence the probability and rate of capture:

- “Year” (7 Levels)
-2006-2012

- “Time of Day”(4 Levels): the time of day the set started defined from the time the first hook was set in the water
-22.1 to 4.0 hrs =Night
-4.1 to 10.0=Dawn
-10.1 to 16.0=Day
-16.1 to 22.0 hrs=Dusk

- “Season” (4 Levels)
-Winter = January-March
-Spring = April-June
-Summer = July-September
-Fall = October-December

- “Depth” (4 levels): defined as the mean depth (m) when the first hook was set and the last hook was retrieved
-0-100 m
-100-200 m
-200-300 m
->300 m

- “Hook type” (Levels): the hook that was used by the majority of the set
- Circle hook types 10-15, 6, 9
- Not defined or multiple hook types

We attempted to classify bait into a categorical variable however the extreme variability in the types of bait used for a particular set precluded adding this variable to the analysis.

The proportion of sets that caught *Mustelus* spp. (when at least one fish was caught) was modeled assuming a binomial distribution with a logit link function. Positive catches were modeled using a dependent variable of the natural logarithm of CPUE expressed as the number of fish caught per 100 hook hrs

$$\text{CPUE} = \log\{(\text{fish kept} + \text{fish released}) / ((\text{number of hooks} / 100) * \text{soak})\}$$

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 provided 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). 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.

Results and Discussion

The final bottom longline dataset analyzed contained 2917 sets. Of those sets, *Mustelus* spp. were reported caught on 14.4% of sets. The stepwise construction of the model is summarized in Table 1 and the index statistics can be found in Table 2. Table 3 provides a table of the frequency of observations by factor and level. The standardized abundance index is shown in Figure 1 and the diagnostic plots assessing the fit of the models are in Figure 2.

Table 1. Analysis of deviance of explanatory variables for the binomial and lognormal generalized linear and mixed model formulations of the proportion of positive and positive catches for *Mustelus* spp.. Final models selected are in bold.

Proportion positive-Binomial error distribution					
FACTOR	DEVIANCE/DF	%DIF	DELTA	CHISQUARE	PR>CHI
NULL	3.90				
YEAR	3.35	14.00	14.00	181.13	<.0001
YEAR+					
SETDEPTH	2.13	45.28	31.28	358.95	<.0001
HOOKTYPE	2.99	23.26		Negative of Hessian not positive definite.	
SEASON	3.12	19.95		76.53	<.0001
SETBEGIN	3.37	13.53		4.87	0.18
YEAR+SETDEPTH+					
SEASON	2.11	46.00	0.72	14.39	0.00
MIXED MODEL	AIC				
YEAR+SETDEPTH+SEASON	184.10				
YEAR+SETDEPTH+SEASON YEAR*SETDEPTH	183.50				
YEAR+SETDEPTH+SEASON YEAR *SEASON	186.10				

Proportion positive-Lognormal error distribution					
FACTOR	DEVIANCE/DF	%DIF	DELTA	CHISQUARE	PR>CHI
NULL	2.58				
YEAR	2.04	20.95	20.95	105.25	<.0001
YEAR+					
HOOKTYPE	1.68	34.97	14.02	87.55	<.0001
SEASON	1.95	24.25		21.09	0.00
SETDEPTH	1.99	23.05		14.41	0.00
SETBEGIN	2.02	21.89		8.11	0.04
YEAR+HOOKTYPE+					
SETDEPTH	1.64	36.40	1.43	12.47	0.01
SEASON	1.65	36.16		10.83	0.01
SETBEGIN	1.65	35.98		9.69	0.02
MIXED MODEL	AIC				
YEAR+HOOKTYPE+SETDEPTH	1408.80				
YEAR+HOOKTYPE+SETDEPTH YEAR*HOOKTYPE	1372.10				
YEAR+HOOKTYPE+SETDEPTH YEAR*SEASON	1403.20				

Table 2. The standardized and nominal index of absolute abundance, and coefficients of variation (CV) for *Mustelus* spp. N = number of sets.

YEAR	N	ABSOLUTE STANDARDIZED INDEX	CV	ABSOLUTE NOMINAL INDEX	CV
2006	228	0.017	3.86	0.002	35.336
2007	363	0.006	4.96	0.004	6.933
2008	273	0.104	0.88	0.451	0.202
2009	737	0.056	1.21	0.051	1.338
2010	531	0.037	1.64	0.029	2.060
2011	225	0.136	1.51	0.028	7.256
2012	560	0.098	1.02	0.127	0.789

Table 3. Frequency of observations by factor and level used in the development of the standardized catch rate series.

FACTOR	LEVEL	FREQUENCY OF TOTAL
Year	2006	7.8
	2007	12.4
	2008	9.4
	2009	25.3
	2010	18.2
	2011	7.7
	2012	19.2
	Time of Day	Dawn
Day		44.0
Dusk		12.5
Night		1.7
Season	Fall	22.2
	Spring	34.4
	Summer	14.3
	Winter	29.1
Hook Type	C10	0.5
	C11	0.3
	C12	4.7
	C13	45.9
	C14	32.3
	C15	4.3
	C6	0.2
	C9	0.8
	OTHER	10.9
Set Depth	0-100	41.8
	100-200	44.0
	200-300	12.5
	300>	1.7

Figure 1. Nominal (obscpue) and standardized (STDCPUE) indices of abundance for *Mustelus spp.*. The dashed lines are the 95% confidence limits (LCL, UCL) for the standardized index. Each index has been divided by the maximum of the index.

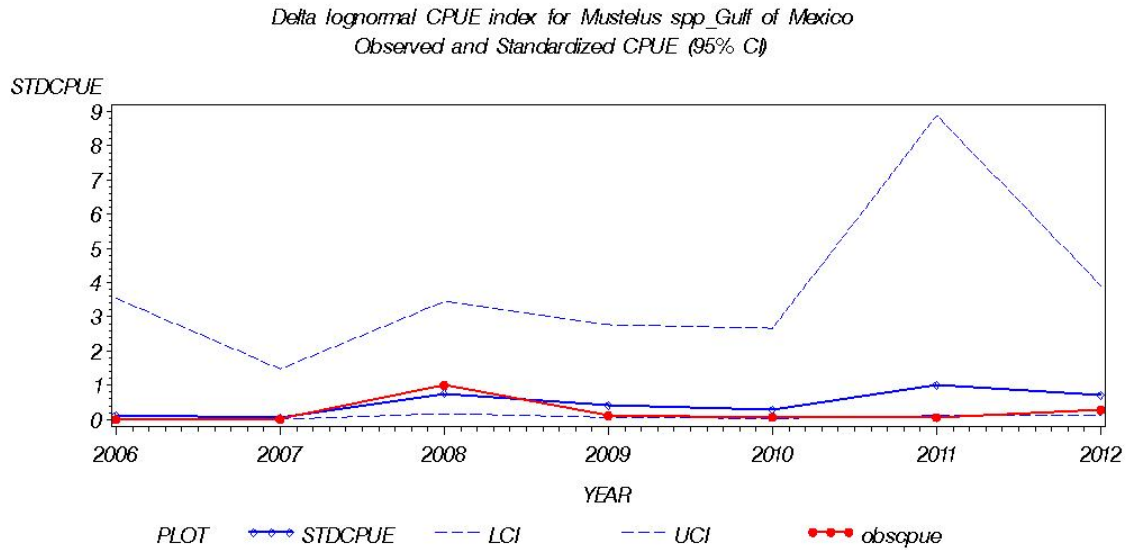
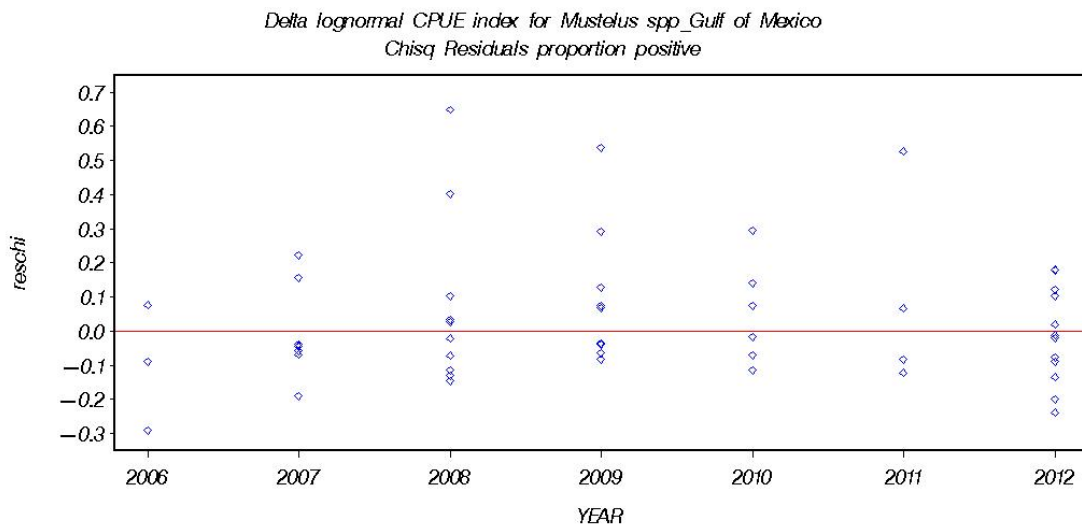
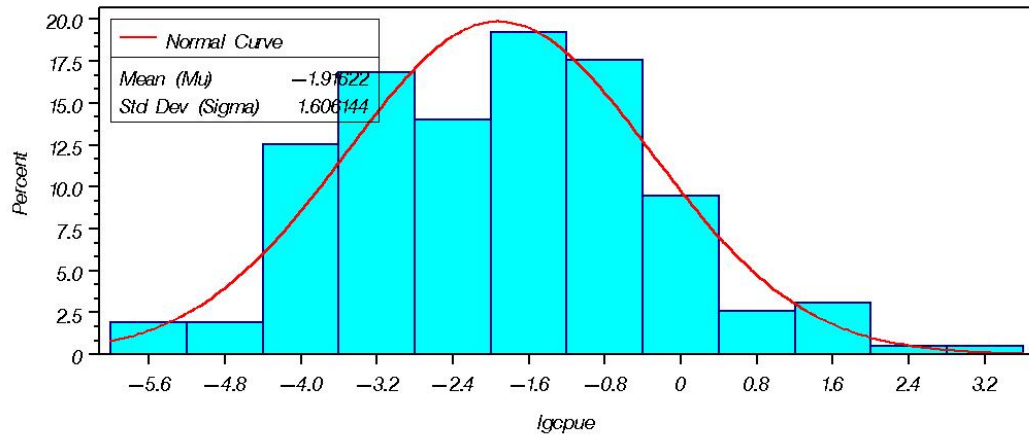


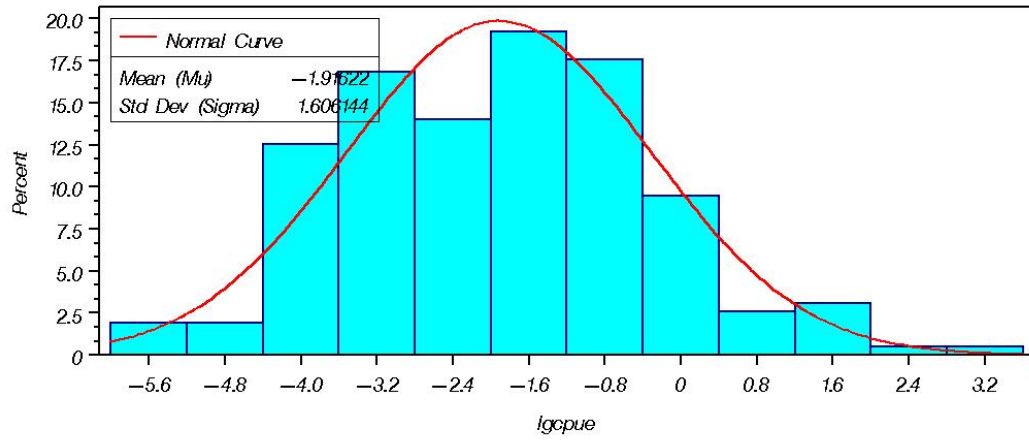
Figure 3. Diagnostic plots of the frequency distribution of residuals, quantile-quantile plots, and distribution of residuals by year for *Mustelus spp.* analysis.



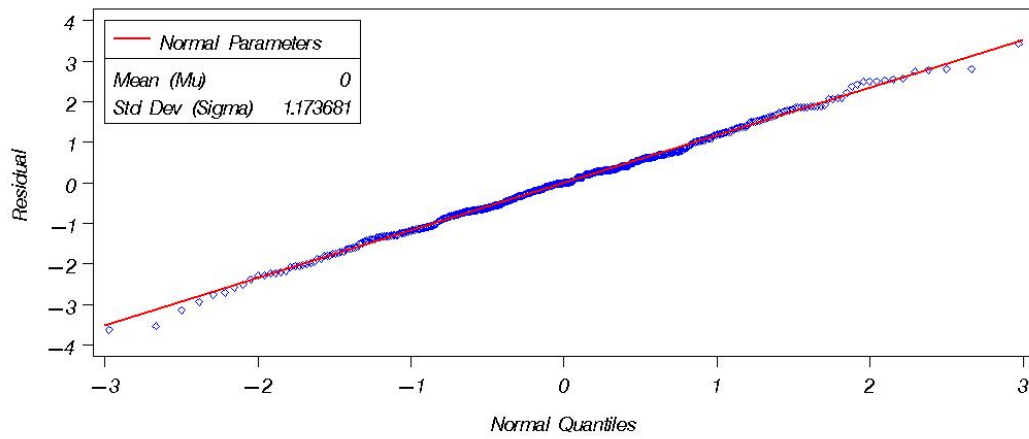
Delta lognormal CPUE index for *Mustelus spp.* Gulf of Mexico
 Frequency distribution log CPUE positive catches



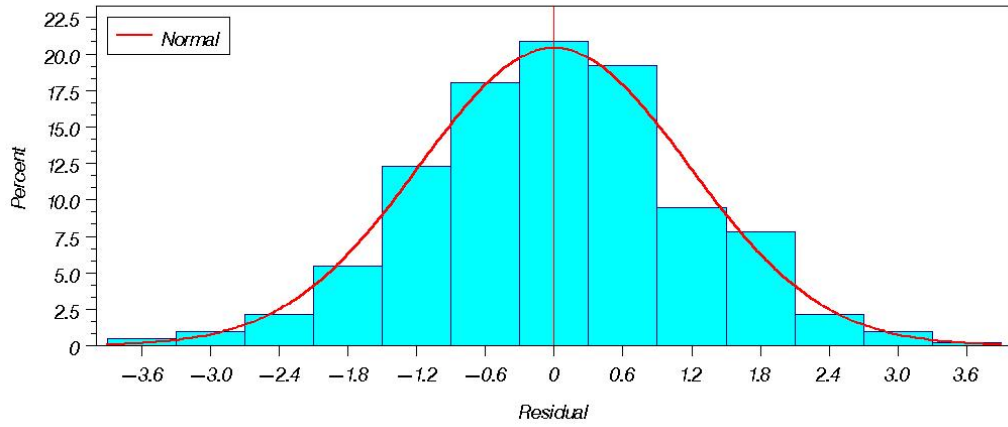
Delta lognormal CPUE index for *Mustelus spp.* Gulf of Mexico
 Frequency distribution log CPUE positive catches



Delta lognormal CPUE index for *Mustelus spp.* Gulf of Mexico
 QQplot residuals Positive CPUE rates



Delta lognormal CPUE index for *Mustelus spp.* Gulf of Mexico
Residuals positive CPUE Distribution



Delta lognormal CPUE index for *Mustelus spp.* Gulf of Mexico
Residuals positive CPUEs * Year

