Standardized indices of abundance for Smooth Dogfish, *Mustelus canis*, from the Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) longline surveys in Delaware Bay

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SEDAR 39 DATA WORKSHOP DOCUMENT

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Summary

This document details the smooth dogfish catch from the Northeast Fisheries Science Center, Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) survey conducted in Delaware Bay from 2001 to 2013 in July and August. Catch per unit effort (CPUE) in number of sharks per 50-hook hours was used to examine smooth dogfish relative abundance by year. The CPUE was standardized using a two-step delta-lognormal approach originally proposed by Lo et al (1992) that models the proportion of positive catch with a binomial error distribution separately from the positive catch, which is modeled using a lognormal distribution. The nominal and standardized relative abundance for smooth dogfish shows an overall decreasing trend in relative abundance across the time series. The timing of this survey does not coincide with the peak use of Delaware Bay by smooth dogfish in late spring; therefore, this survey may not provide annual estimates of relative abundance that represent the true trend in abundance over time.

Introduction

Researchers from the NEFSC Apex Predators Program (APP) have been conducting gillnet and/or longline surveys for sharks in Delaware Bay since 1995, and as part of the Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) program since 1998. In 2001, a juvenile shark bottom longline survey using a random stratified sampling plan based on depth and geographic location was initiated, primarily to assess and monitor the juvenile sandbar shark, *Carcharhinus plumbeus*, population of the Bay. Smooth dogfish, *Mustelus canis*, are a common shark species caught during this survey. In this document, the COASTSPAN longline time series is modeled to create a standardized index of abundance for the smooth dogfish.

Methods

Sampling Gear and Data Collection

A 50-hook bottom longline was used at random stratified sampling stations based on depth and geographic location during the summer months from 2001 to 2013. The mainline consisted of 305 m (1000 ft) of 0.64 cm (1/4 in) braided nylon mainline, and 50 gangions comprised of 12/0 Mustad circle hooks with barbs depressed, 50 cm of 1/16 stainless cable, and 100 cm (39 in) of 0.64 cm (1/4 inch) braided nylon line with 4/0 longline snaps. The 50 gangions were placed along the mainline in 6 m (20 ft) intervals. Longline soak time was approximately 30 minutes. Hooks were baited with thawed Atlantic mackerel, *Scomber scombrus*. The gear was set with weights and/or anchors to maintain position and enough line to account for the depth at the sampling location for attachment to a fluorescent ball buoy and a staff buoy with a fluorescent flag to mark each end of the gear. Station location, water and air temperatures, depth, salinity, and time of day were recorded for each set. When possible, bottom type was determined by observing bottom sediment on the anchor. The sex, weight, fork length, and total length of all sharks were recorded.

Sampling Design

A random stratified sampling plan based on depth and geographic location was initiated in July 2001. The Bay was split into nine different geographic regions, three across the northern section of the Bay (NW, NC, NE), three across the middle section of the Bay (CW, CC, CE) and three across the southern section of the Bay (SW, SC, SE) (Figure 1). Within each of these regions, different sampling areas were determined based on the mean low water depth strata (0-2 m, 2-5 m, 5-10 m, and 10+ m) located within that region (Figure 1). The geographic regions and depth strata ranges were chosen based on differences seen during sampling for juvenile sandbar sharks in Delaware Bay by the National Marine Fisheries Service from 1995 to 2000. In some locations throughout the Bay where small areas of one depth stratum occur within another, and there is no significant difference between catch rates during historical sampling in these areas, the two areas are combined into one sample area under the larger of the two depth strata. When a depth stratum from one geographic region crosses into another geographic region, but only a very small portion, then that small portion will remain attached to the larger portion in the original geographic region.

Depth data used in this study were derived from a bathymetric digital elevation model (30 m resolution) based on 17 surveys containing 321,774 soundings in Delaware Bay conducted by the National Ocean Service (NOS). The surveys dated from 1945 to 1993. This data was verified and corrected using field observations and a geographically referenced, digital version of the 2000 NOS nautical chart of Delaware Bay (# 12304).

Stations in each depth stratum within the nine geographic regions of the Bay were chosen randomly from a list of every point (latitude, longitude) within that depth stratum in decimal degrees out to four decimal places. A macro was created in Excel that randomly chose a station from these lists of possible station locations for each month sampled.

Data Analysis

Catch per unit effort (CPUE) in number of sharks per 50-hook set per hour was used to examine the relative abundance of smooth dogfish caught during the COASTSPAN longline survey conducted from 2001 to 2013 in Delaware Bay. The CPUE was standardized using the Lo et al. (2002) method, which models the proportion of positive sets separately from the positive catch. Factors considered as potential influences on CPUE were: year (2001-2013), month (July and August), depth (0-2, 2-5, 5-10 and 10+ m) and region (NW, NC, NE, CW, CC, CE, SW, SC, SE). The proportion of sets with positive catch values was modeled assuming a binomial distribution with a logit link function and the positive catch sets were modeled assuming a lognormal distribution.

Models were fit in a stepwise forward manner adding one potential factor at a time after initially running a null model with no factors included (Gonzáles-Ania et al. 2001, Carlson 2002). Each potential factor was ranked from greatest to least reduction in deviance per degree of freedom when compared to the null model. The factor resulting in the greatest reduction in deviance was then incorporated into the model provided the deviance per degree freedom was reduced by at least 1% from the less complex model. This process was continued until no additional factors met the criteria for incorporation into the final model. The factor “year” was kept in all final models, regardless of its significance, to allow for calculation of indices. All models in the stepwise approach were fitted using the SAS GENMOD procedure (SAS Institute, Inc.). The final models were then run through the SAS GLIMMIX macro to allow fitting of the generalized linear mixed models using the SAS MIXED procedure (Wolfinger, SAS Institute, Inc). The standardized indices of abundance were based on the year effect least square means determined from the combined binomial and lognormal components.

Results

A total of 1291 smooth dogfish were caught during 690 longline sets from 2001 to 2013. Smooth dogfish ranged in length from 26 to 122 cm FL (Figure 2). The proportion of sets with positive catch (at least one smooth dogfish caught) was 45%. The stepwise construction of each model and the resulting statistics for the mixed models are detailed in Table 1. Model diagnostic plots reveal that the model fit is acceptable (Figures 3a and 3b). The resulting indices of abundance based on the year effect least square means, associated statistics and nominal indices are reported in Table 2 and are plotted by year in Figure 4. The nominal and standardized relative abundance for smooth dogfish shows an overall decreasing trend in relative abundance across the time series. The timing of this survey does not coincide with the peak use of Delaware Bay by smooth dogfish in late spring; therefore, this survey may not provide annual estimates of relative abundance that represent the true trend in abundance over time.

References

Carlson J.K. 2002. A fishery-independent assessment of shark stock abundance for large coastal species in the northeast Gulf of Mexico. Panama City Laboratory Contribution Series 02-08. 26pp.

González-Ania, L.V., C.A. Brown, and E. Cortés. 2001. Standardized catch rates for yellowfin tuna (*Thunnus albacares*) in the 1992-1999 Gulf of Mexico longline fishery based upon observer programs from Mexico and the United States. Col. Vol. Sci. Pap. ICCAT 52:222-237.

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Table 1. Results of the stepwise procedure for development of the COASTSPAN Delaware Bay longline (2001-2013) catch rate model for smooth dogfish. %DIF is the percent difference in deviance/DF between each model and the null model. Delta% is the difference in deviance/DF between the newly included factor and the previous entered factor in the model. L is the log likelihood.

PROPORTION POSITIVE-BINOMIAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%
NULL	673	928.6224	1.3798		
DEPTH	670	862.6809	1.2876	6.6821	6.6821
REGION	655	873.4760	1.3135	4.8050	
YEAR	661	885.8848	1.3402	2.8700	
MONTH	672	927.5877	1.3803	-0.0362	
DEPTH +					
YEAR	658	813.9471	1.2370	10.3493	3.6672
REGION	662	825.9106	1.2476	9.5811	2.8990
DEPTH + YEAR +					
REGION	650	774.7804	1.1920	13.6107	3.2613

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
DEPTH + YEAR + REGION	3050.6	3055.1	3048.6

Type 3 Test of Fixed Effects

Significance (Pr>Chi) of Type 3	DEPTH	YEAR	REGION
test of fixed effects for each factor	<.0001	<.0001	<.0001
DF	3	12	8
CHI SQUARE	44.96	44.07	34.21

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%
NULL	327	265.3045	0.8113		
DEPTH	324	240.7531	0.7431	8.4063	8.4063
YEAR	315	237.0254	0.7525	7.2476	
REGION	319	246.9157	0.7740	4.5976	
MONTH	326	264.2778	0.8107	0.7740	
DEPTH +					
YEAR	312	213.4414	0.6841	15.6785	7.2723
REGION	316	228.7325	0.7238	10.7852	2.3789
MONTH	323	239.2589	0.7407	8.7021	0.2958
DEPTH + YEAR +					
REGION	304	200.5931	0.6598	18.6737	2.9952

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
DEPTH + YEAR + REGION	816.3	820.0	814.3

Type 3 Test of Fixed Effects

Significance (Pr>Chi) of Type 3	DEPTH	YEAR	REGION
test of fixed effects for each factor	<.0001	<.0001	0.0125
DF	3	12	8
CHI SQUARE	27.48	42.65	19.47

Table 2. Smooth dogfish analysis number of sets per year (n obs), number of positive sets per year (obs pos), proportion of positive sets per year (obs ppos), nominal cpue as sharks per hook (obs cpue), resulting estimated cpue from the model (est cpue), the lower 95% confidence limit for the est cpue (LCL), the upper 95% confidence limit for the est cpue (UCL), and the coefficient of variation for the estimated cpue (CV).

year	n obs	obs pos	obs ppos	obs cpue	est cpue	LCL	UCL	CV
2001	56	41	0.7321	7.8571	7.6902	5.4155	10.9204	0.1767
2002	56	29	0.5179	2.1786	2.8404	1.7370	4.6447	0.2497
2003	56	22	0.3929	5.6786	3.8818	2.1268	7.0849	0.3078
2004	56	32	0.5714	5.5536	6.0776	3.8773	9.5266	0.2276
2005	56	28	0.5000	4.0771	3.3770	2.0390	5.5931	0.2563
2006	55	25	0.4545	3.6584	3.0781	1.7762	5.3341	0.2802
2007	56	25	0.4464	2.9449	2.5951	1.4966	4.4999	0.2805
2008	56	24	0.4286	3.3740	2.9009	1.6336	5.1513	0.2931
2009	56	20	0.3571	2.2234	1.6188	0.8524	3.0740	0.3291
2010	43	28	0.6512	3.3247	4.1050	2.6245	6.4206	0.2265
2011	43	24	0.5581	2.7507	2.8575	1.6927	4.8238	0.2664
2012	55	16	0.2909	0.9145	1.0387	0.5004	2.1564	0.3777
2013	45	14	0.3111	1.9573	1.4177	0.6570	3.0594	0.3992

Figure 1: Bathymetric map of Delaware Bay showing the nine geographic regions and the four depth strata used during this study

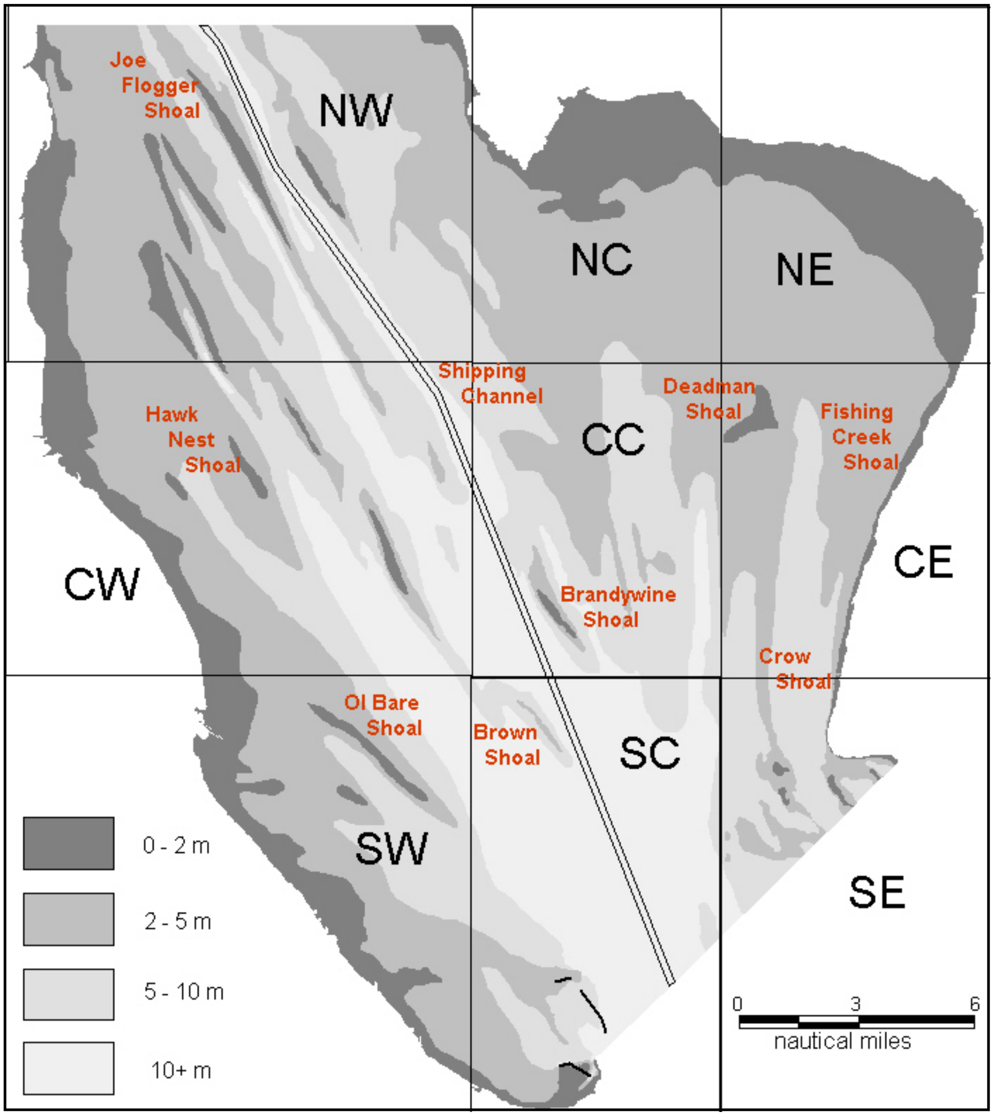


Figure 2. Fork lengths (cm) of total juvenile sandbar sharks caught by year from 2003-2013

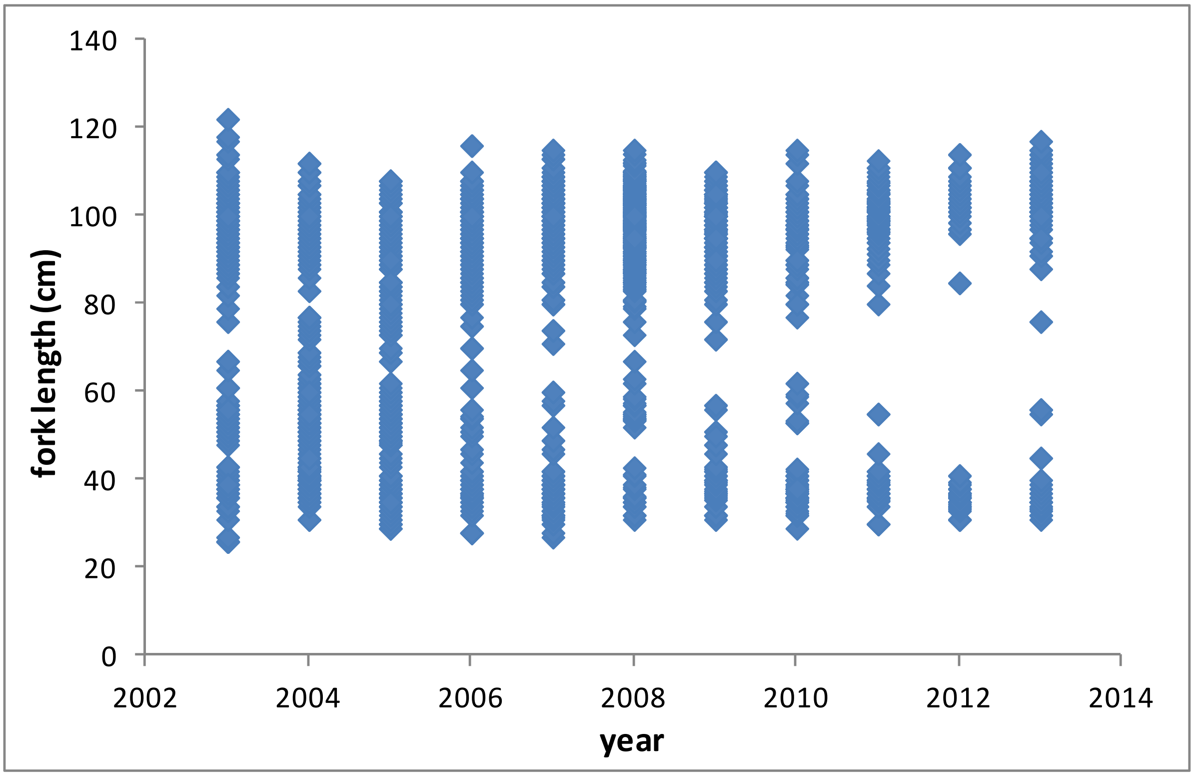


Figure 3a. Diagnostic plots for the binomial component.

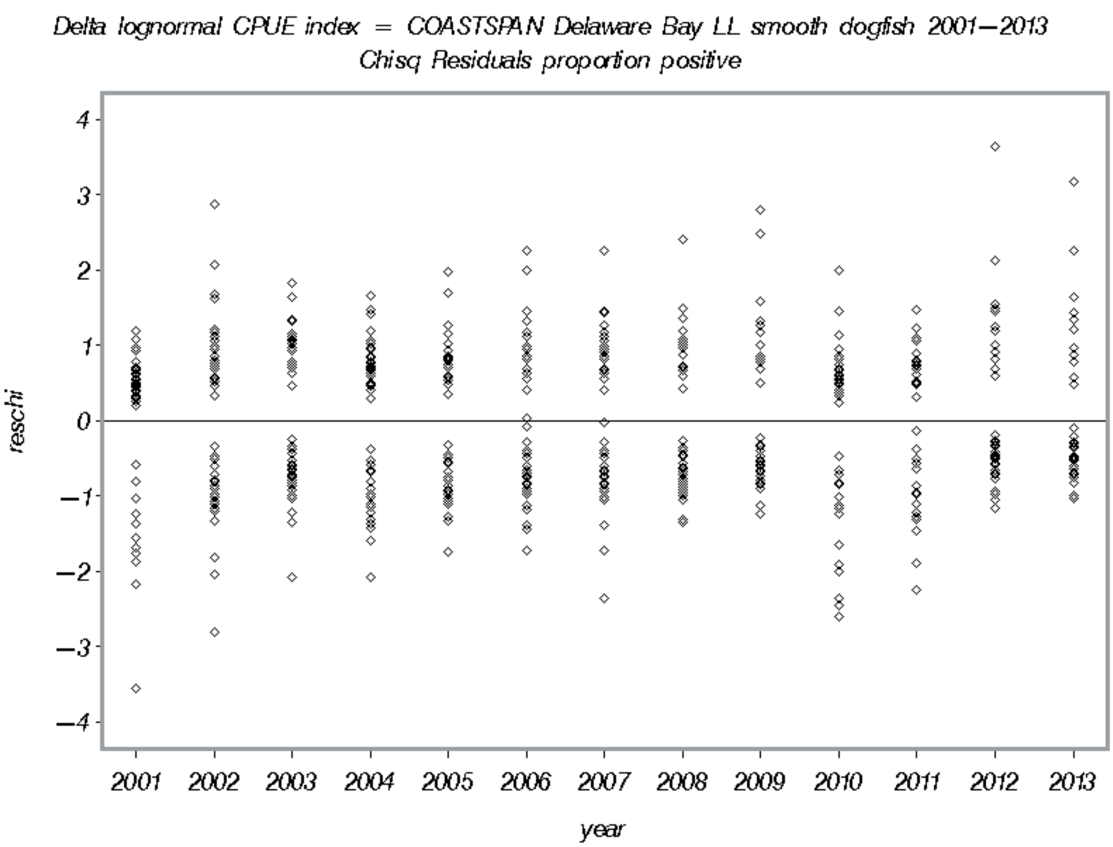
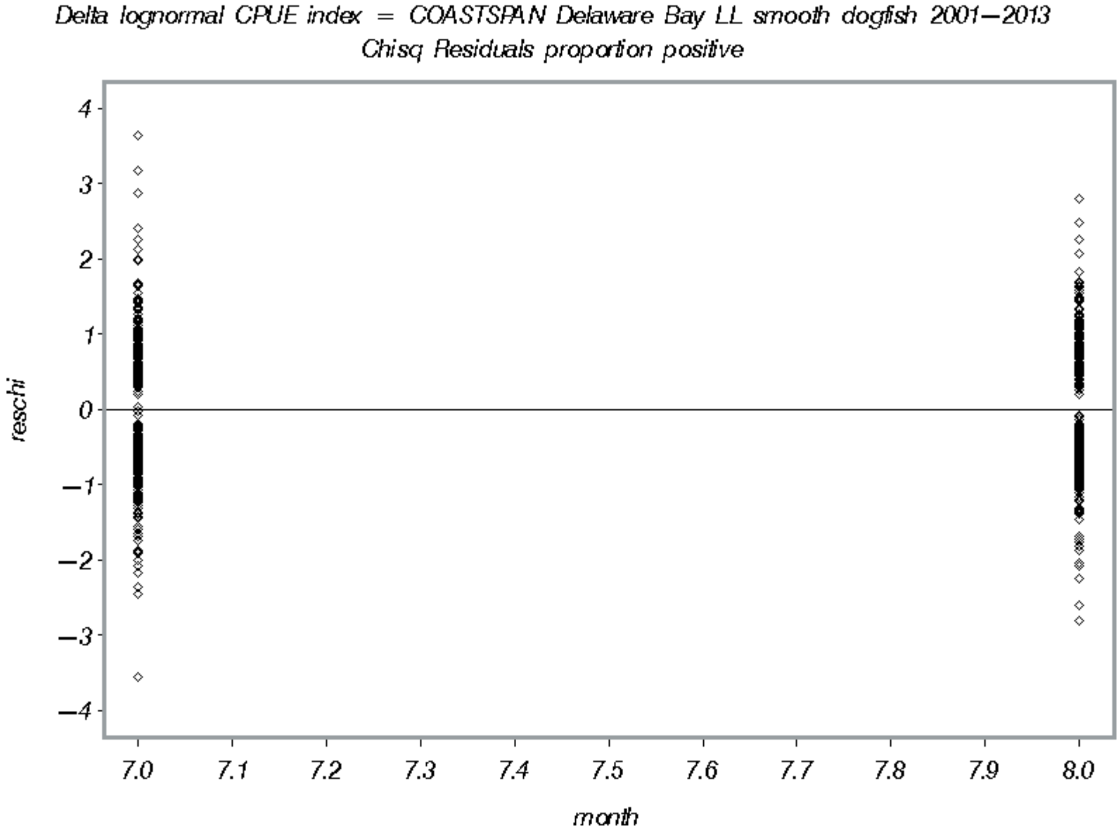


Figure 3a continued. Diagnostic plots for the binomial component.



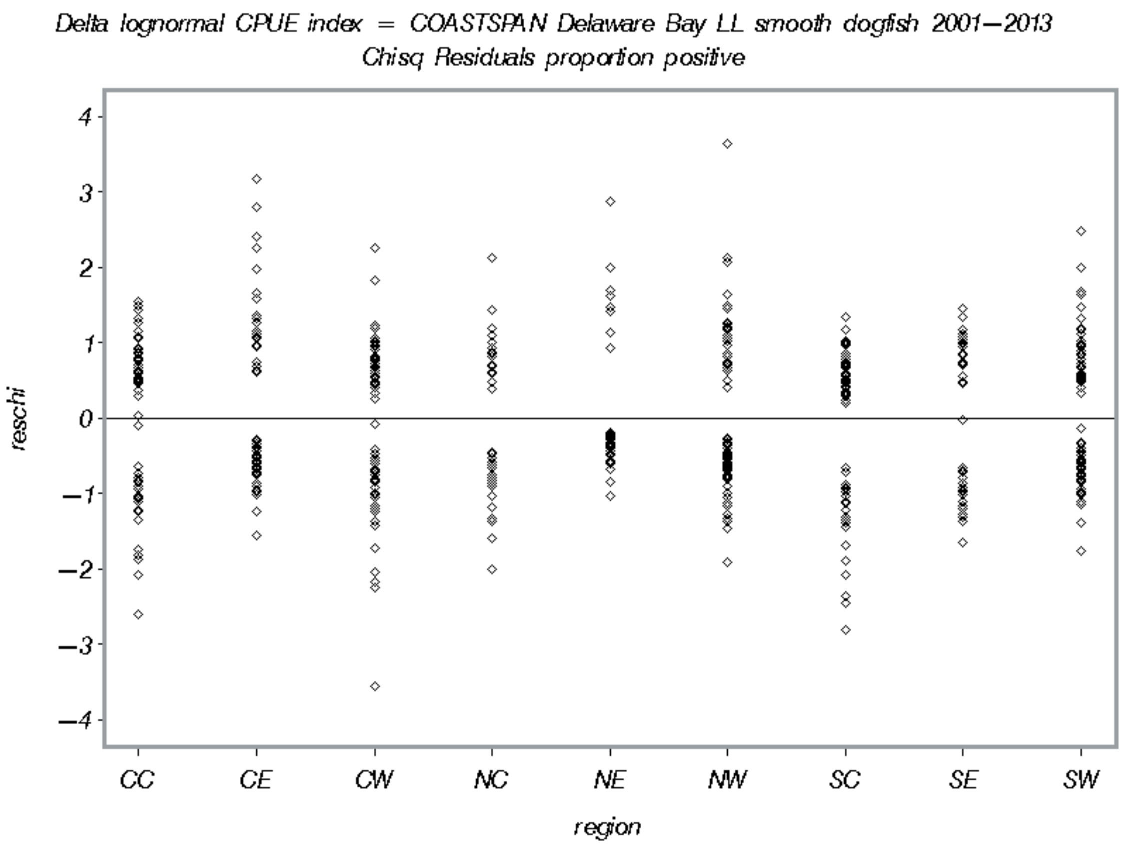


Figure 3a continued. Diagnostic plots for the binomial component.

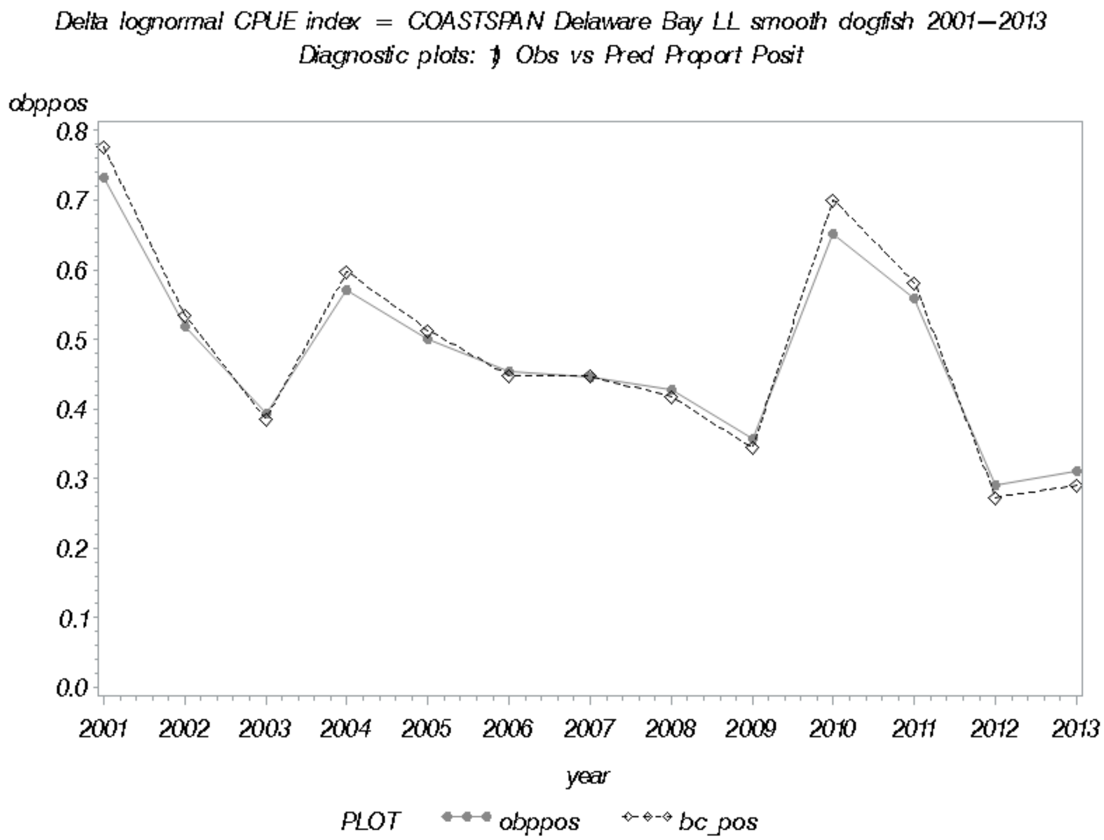


Figure 3b. Diagnostic plots for lognormal component.

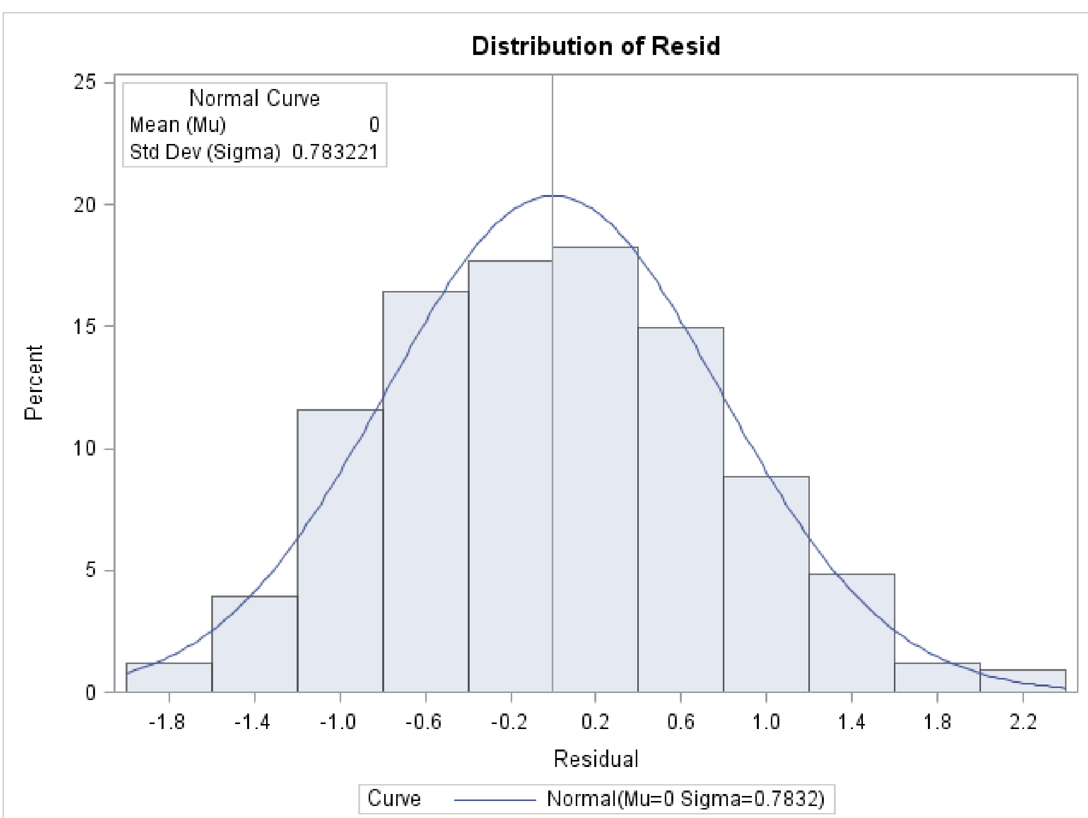
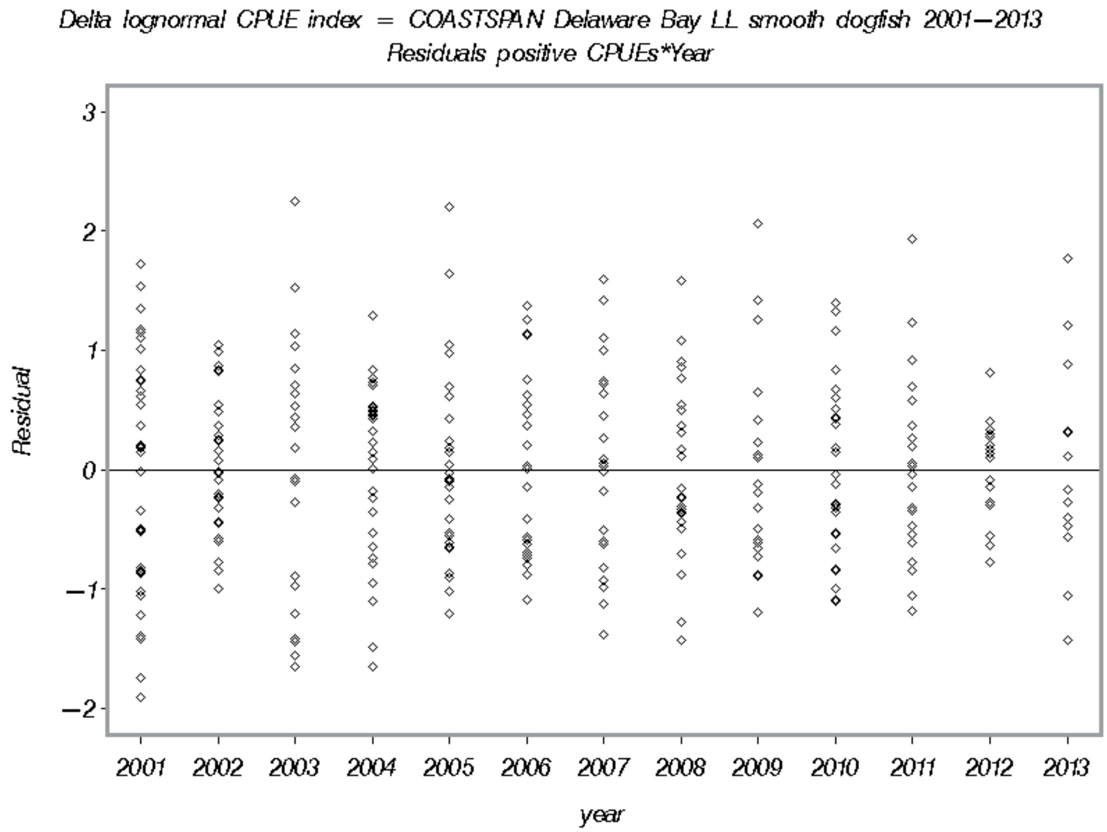


Figure 3b continued. Diagnostic plots for lognormal component.



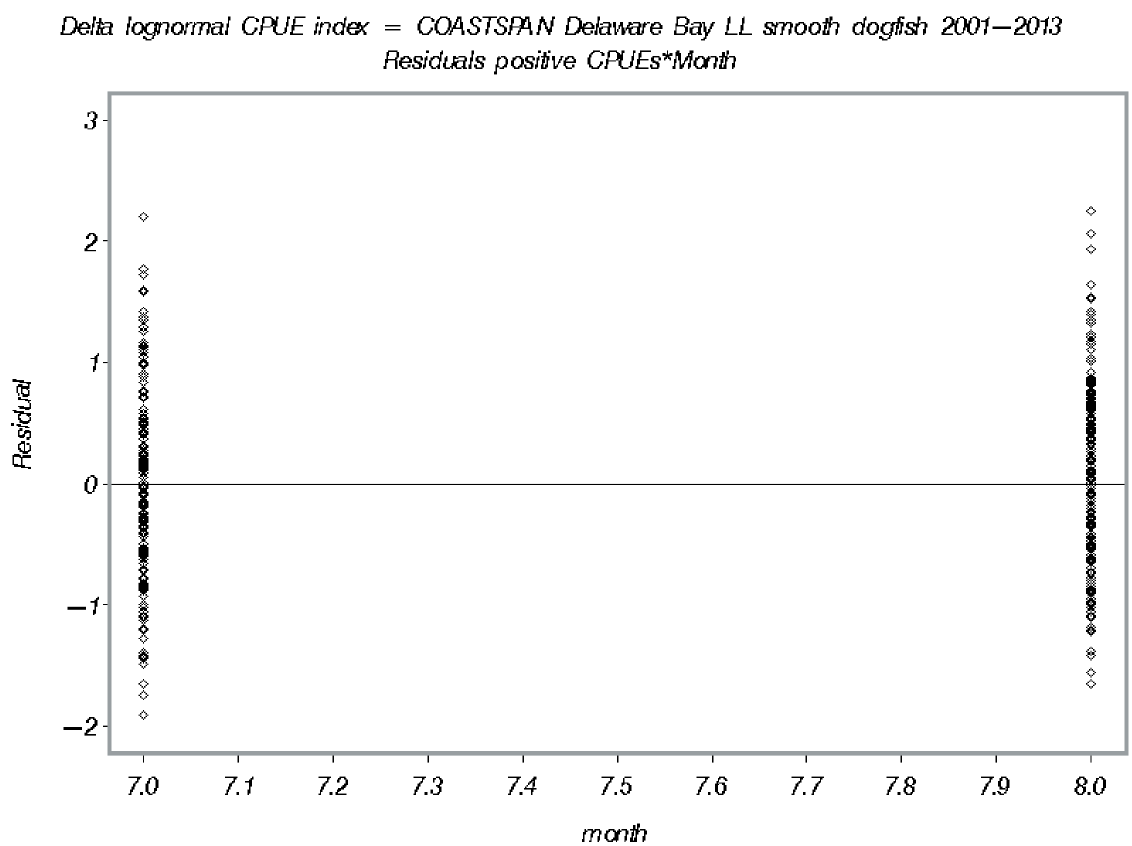
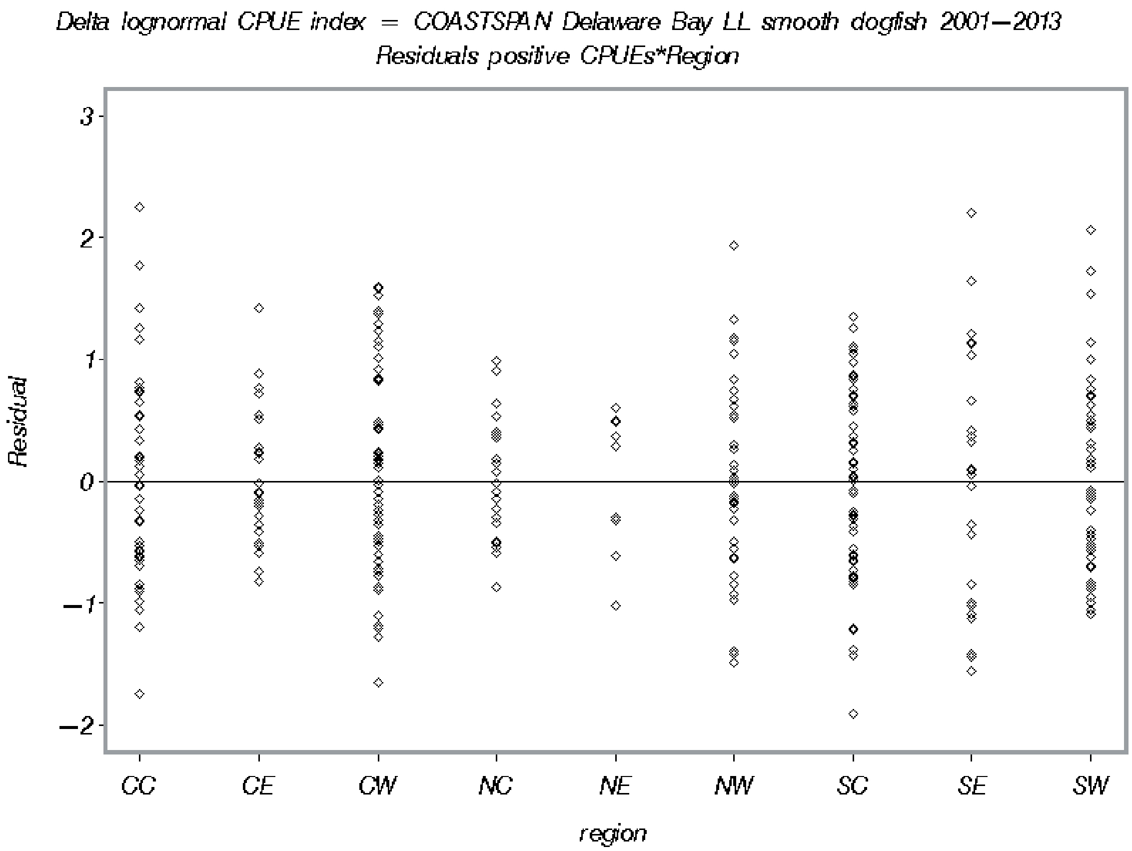


Figure 3b continued. Diagnostic plots for lognormal component.



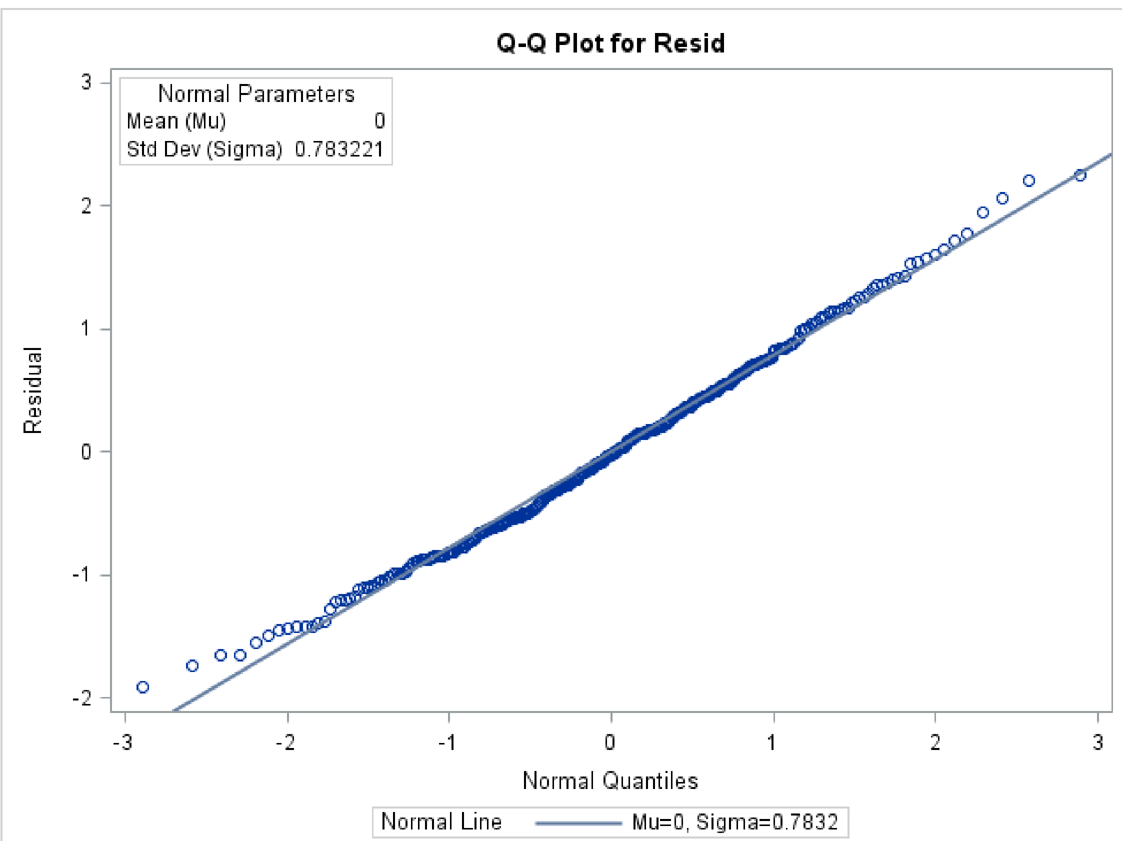


Figure 4. Smooth dogfish nominal (obscpue) and estimated (estcpue) indices with 95% confidence limits (LCI0, UCI0)