Standardized catch rates for sandbar sharks from SEAMAP longline surveys conducted by GADNR and SCDNR

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SEDAR 101 DATA WORKSHOP DOCUMEMT

Standardized catch rates for sandbar sharks from SEAMAP longline surveys conducted by GADNR and SCDNR

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Summary

This document details the sandbar shark catches from the Southeast Area Monitoring and Assessment Program (SEAMAP) longline surveys conducted by the Georgia Department of Natural Resources (GADNR) and the South Carolina Department of Natural Resources (SCDNR) from 2007-2024. Catch per unit effort (CPUE) in number of sharks per 100 hook-hours were used to standardize sandbar shark CPUE for sharks 80 cm fork length (FL) and greater. 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. Sandbar sharks (≥ 80 cm FL) showed a decreasing trend until 2011 when relative abundance appears to stabilize and then has an overall increasing trend throughout the remainder of the time series with increasing interannual variability after 2018.

Introduction

The Southeast Area Monitoring and Assessment Program (SEAMAP) longline surveys conducted by the Georgia Department of Natural Resources (GADNR) and the South Carolina Department of Natural Resources (SCDNR) were primarily developed to monitor adult red drum in South Carolina, Georgia, and northern Florida's nearshore waters. Previously, an adult red drum survey was conducted in South Carolina waters through 2006. The survey methods changed and a new time series began in 2007. GADNR and SCDNR provide information on shark catches during the SEAMAP longline surveys for use in the SEDAR process for U.S. Atlantic sharks. SEAMAP data for both the GADNR and SCDNR surveys were combined and standardized as a single index for use in SEDAR 54. Based on recommendations coming out of the SEDAR 101 Indices Working Group, the index was run both from 2007-2024 and from 2009-2024. The latter to avoid trying to capture a gear change and incorporate bait as a potential factor in the model.

Methods

Sampling Gear and Data Collection

For information on the sampling gear and data collection methods used by GADNR and SCDNR during the SEAMAP longline surveys see the previous SEDAR working documents: SEDAR34-WP34 and SEDAR34-WP36. In these working papers, the SEAMAP longline surveys are referred to as red drum longline (GADNR) and new red drum longline (SCDNR) surveys, respectively.

Data Analysis

Catch per unit effort (CPUE) in number of sharks per hook hour were used to standardize sandbar shark CPUE for sharks 80 cm fork length (FL) and greater. The CPUEs were 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 the survey sets were: year (2007 – 2024), month (May – September), temperature (<20 deg C, 20-24 deg C, 25+ deg C), salinity (<25 ppt, 25-29 ppt, 30-34 ppt, 35+ ppt), depth (<10 m, 10+ m), area (Winyah Bay, Charlestown Harbor, St Helena Sound, Port Royal Sound, southern Georgia, northern Florida) and set number (sequential set number in a given day of sampling). Following some data checks for changes since the last assessment, a separate model was also run including only the months from August to November and excluding data from the northern Florida region as the timing of the surveys by both agencies shifted towards the fall and the northern Florida region has not been sampled since 2017, 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 effect was significant at $\alpha = 0.05$ based on a Chi-Square test, and 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. Single factors were incorporated first, followed by fixed first-level interactions. 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), in which all interactions including the "year" factor were treated as a random effect. 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 1900 sandbar sharks (≥ 80 cm FL) were caught during 9893 longline sets from 2007 to 2024. The size range of for these sandbar sharks is displayed by year and by sex and year in Figure 1. The proportion of sets with positive catch (at least one sandbar shark caught) was 12%. Histograms of set catch data show a persistent zero-inflated distribution, appropriate for standardization with the delta-lognormal model (Figure 2). After initial review by the Indices working group and discussions with personnel that run the survey, it was decided that the time series should start at 2009 and bait should be considered as a factor in the model. The stepwise construction of each model is detailed in Tables 1 and 2. Model diagnostic plots reveal that the model fit for each run is reasonable (Figures 3, 4, 7,and 8). The resulting indices of abundance based on the year effect least square means, associated statistics and nominal indices are reported in Tables 3 and 4 and are plotted by year in Figures 5 and 9. A plot of the index re-modeled after removing the last year, 5 consecutive times, is located in Figure 6 for retrospective analysis.

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.

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.

Table 1. Results of the stepwise procedure for development of the SEAMAP LL ATL catch rate model for sandbar sharks (80+ cm FL) for **2007-2024** using the SAS GENMOD procedure. %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.

PROPORTION POSITIVE-BINOMIAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE	%DIFF	DELTA%	CHISQ	PR>CHI
null	7760	6171.9972	0.7952				
area	7755	5617.5830	0.7244	8.903		553.41	<.0001
survey	7759	5932.5481	0.7646	3.848		238.45	<.0001
month	7751	5998.6094	0.7739	2.679		172.39	<.0001
year	7743	6036.1127	0.7796	1.962		134.88	<.0001
sal	7757	6058.0121	0.7810	1.786		112.99	<.0001
temp	7758	6101.6859	0.7865	1.094		69.31	<.0001
depth	7759	6109.6403	0.7874	0.981		61.36	<.0001
set	7738	6153.0734	0.7952	0		17.92	0.7105
AREA +							
year	7738	5524.5537	0.7140	10.211	1.3078	93.03	<.0001
sal	7752	5531.3266	0.7135	10.274	1.3707	86.26	<.0001
month	7746	5562.1081	0.7181	9.696	0.7923	55.47	<.0001
temp	7753	5579.7942	0.7197	9.494	0.5910	37.79	<.0001
depth	7754	5609.2227	0.7234	9.029	0.1258	8.36	0.0038
survey	7755	5617.583	0.7244	8.903	0.0000	0	.
AREA + YEAR +							
sal	7735	5420.4107	0.7008	11.871	1.6600	104.14	<.0001
AREA + YEAR + SAL +							
year*area	7661	5249.7128	0.6853	13.820	1.9492	negative hessian	
year*sal	7686	5268.6067	0.6855	13.795	1.9240	negative hessian	
area*sal	7720	5340.9188	0.6918	13.003	1.1318	negative hessian	

FINAL MODEL: AREA + YEAR + SAL

Type 3 Test of Fixed Effects Results for the Final Model using SAS MIXED procedure

Significance (Pr>Chi) of Type 3	area	year	sal
test of fixed effects for each factor	<.0001	<.0001	<.0001
DF	5	17	3
CHI SQUARE	205.01	49.28	40.8

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE	%DIFF	DELTA%	CHISQ	PR>CHI
null	1099	297.4935	0.2707				
area	1094	277.3504	0.2535	6.3539		77.12	<.0001
year	1082	288.1468	0.2663	1.6254		35.11	0.006
survey	1098	291.8054	0.2658	1.8101		21.24	<.0001
month	1091	293.1080	0.2687	0.7388		16.34	0.0378
temp	1097	295.3515	0.2692	0.5541		7.95	0.0188
depth	1098	296.3548	0.2699	0.2955		4.22	0.0400
sal	1096	296.917	0.2709	-0.0739		2.13	0.5451
set	1078	293.5122	0.2723	-0.5911		14.82	0.8319
AREA +							
year	1077	268.8617	0.2496	7.7946	1.440709	34.19	0.0079
temp	1092	276.0865	0.2528	6.6125	0.258589	5.02	0.0811
survey	1094	277.3504	0.2535	6.3539	0	0.00	.
depth	1093	277.2917	0.2537	6.2800	-0.07388	0.23	0.6294
month	1086	276.0805	0.2542	6.0953	-0.25859	5.05	0.7524
AREA + YEAR +							
year*area	1015	253.88	0.2501	5.4012	-0.2348	63.07	0.4383

FINAL MODEL: AREA + YEAR

Type 3 Test of Fixed Effects Results for the Final Model using SAS MIXED procedure

Significance (Pr>Chi) of Type 3	area	year
test of fixed effects for each factor	<.0001	<.0001
DF	5	17
CHI SQUARE	178.16	51.79

Table 2. Results of the stepwise procedure for development of the SEAMAP LL ATL catch rate model for sandbar sharks for **2009-2024** including bait as a potential factor within the SAS GENMOD procedure. %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.

PROPORTION POSITIVE-BINOMIAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE	%DIFF	DELTA%	CHISQ	PR>CHI
null	6880	5372.4359	0.7809				
area	6875	4873.2622	0.7088	9.233		499.17	<.0001
bait	6873	5144.6514	0.7485	4.149		227.78	<.0001
month	6872	5196.0418	0.7561	3.176		176.39	<.0001
year	6865	5253.706	0.7653	1.998		118.73	<.0001
sal	6877	5286.3046	0.7687	1.562		86.13	<.0001
temp	6878	5321.9411	0.7738	0.909		50.49	<.0001
depth	6879	5323.7507	0.7739	0.896		48.69	<.0001
set	6858	5358.3929	0.7813	-0.051		14.04	0.8999
AREA +							
year	6860	4782.8053	0.6972	10.718	1.4855	90.46	<.0001
sal	6872	4795.4866	0.6978	10.642	1.4086	77.78	<.0001
month	6867	4837.1430	0.7044	9.796	0.5635	36.12	<.0001
bait	6869	4844.7244	0.7053	9.681	0.448	28.54	<.0001
AREA + YEAR +							
sal	6857	4704.2282	0.686	12.153	1.4342	78.58	<.0001
month	6852	4744.7401	0.6925	11.320	0.6019	38.07	<.0001
bait	6854	4777.7666	0.6971	10.731	0.0128	5.04	0.5389
AREA + YEAR + SAL +							
year*area	6789	4558.6966	0.6715	14.009	1.8568	negative hessian	
year*sal	6814	4577.805	0.6718	13.971	1.8184	negative hessian	
area*sal	6842	4631.8716	0.6770	13.305	1.1525	negative hessian	

FINAL MODEL: AREA + YEAR + SAL

Type 3 Test of Fixed Effects Results for the Final Model using SAS MIXED procedure

Significance (Pr>Chi) of Type 3 test of fixed effects for each factor	area	year	sal
DF	5	17	3
CHI SQUARE	205.01	49.28	40.8

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE	%DIFF	DELTA%	CHISQ	PR>CHI
null	951	251.7276	0.2647				
area	946	234.6310	0.2480	6.3090		66.96	<.0001
bait	944	242.7953	0.2572	2.8334		34.39	<.0001
year	936	242.9628	0.2596	1.9267		33.74	0.0037
month	944	247.8554	0.2626	0.7934		14.76	0.0392
temp	949	249.4772	0.2629	0.6800		8.55	0.0139
depth	950	250.4549	0.2636	0.4156		4.83	0.0280
sal	948	250.8605	0.2646	0.0378		3.28	0.3497
set	930	247.6904	0.2663	-0.6045		15.39	0.8028
AREA +							
year	931	226.8288	0.2436	7.9713	1.662	32.19	0.0061
bait	940	230.5780	0.2453	7.3291	1.020	16.59	0.0109
AREA + YEAR +							
bait	925	226.2023	0.2445	7.6313	-0.3400	2.63	0.8533
area*year	874	211.4843	0.2420	8.5757	0.6045	66.68	0.1783

FINAL MODEL: AREA + YEAR

Type 3 Test of Fixed Effects Results for the Final Model using SAS MIXED procedure

Significance (Pr>Chi) of Type 3 test of fixed effects for each factor	area	year
DF	5	17
CHI SQUARE	178.16	51.79

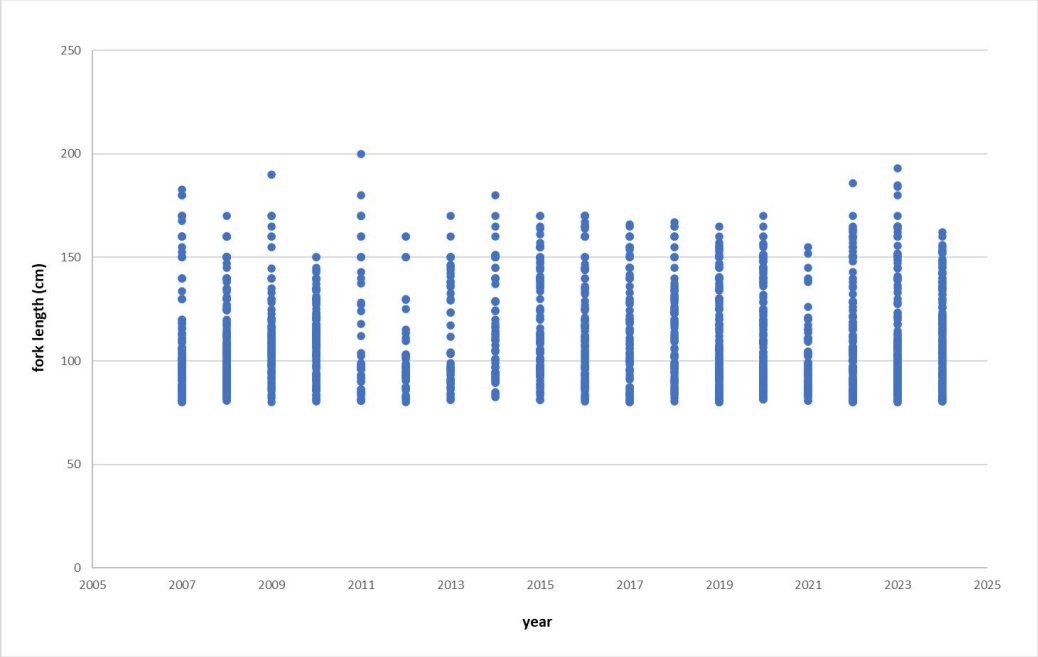
Table 3. SEAMAP LL ATL index results for sandbar sharks (≥ 80 cm FL) **2007-2024**. Table columns: number of sets per year (obs n), number of positive sets per year (obs pos), proportion of positive sets per year (obs ppos), nominal cpue as sharks per hook (obs cpue), resulting estimated cpue from the 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
2007	296	45	0.1520	1.4328	2.0854	1.2803	3.3966	0.2476
2008	636	119	0.1871	1.1185	1.3406	0.9790	1.8357	0.1581
2009	408	59	0.1446	0.7602	1.1733	0.7437	1.8512	0.2310
2010	522	62	0.1188	0.7344	1.0420	0.6675	1.6266	0.2255
2011	469	31	0.0661	0.3483	0.5441	0.2882	1.0274	0.3260
2012	488	38	0.0779	0.3833	0.4881	0.2702	0.8816	0.3022
2013	474	42	0.0886	0.4149	0.4772	0.2732	0.8334	0.2843
2014	486	57	0.1173	0.5359	0.6679	0.4174	1.0687	0.2383
2015	424	59	0.1392	0.7820	0.8656	0.5458	1.3728	0.2337
2016	521	79	0.1516	0.7119	0.7664	0.5078	1.1566	0.2080
2017	489	51	0.1043	0.6356	0.6266	0.3784	1.0375	0.2562
2018	461	54	0.1169	0.7823	0.7226	0.4442	1.1756	0.2470
2019	447	79	0.1767	1.1485	1.5155	1.0360	2.2168	0.1919
2020	404	88	0.2178	1.4223	1.2515	0.8600	1.8214	0.1893
2021	473	47	0.0987	0.6127	0.6438	0.3837	1.0801	0.2631
2022	386	69	0.1799	1.2033	1.2839	0.8226	2.0040	0.2254
2023	450	86	0.1911	1.1915	1.3021	0.8950	1.8945	0.1891
2024	461	85	0.1844	1.1069	1.1068	0.7539	1.6250	0.1938

Table 4. SEAMAP LL ATL index results for sandbar sharks **2009-2024.** See above for column names.

year	n obs	obs pos	obs ppos	obs cpue	est cpue	LCL	UCL	CV
2009	408	59	0.1446	0.7602	1.1612	0.7539	1.7885	0.2185
2010	534	62	0.1161	0.7179	1.0383	0.6846	1.5746	0.2105
2011	479	31	0.0647	0.3410	0.5520	0.3050	0.9990	0.3032
2012	475	34	0.0716	0.3509	0.4593	0.2577	0.8187	0.2951
2013	460	39	0.0848	0.4058	0.4801	0.2799	0.8235	0.2747
2014	477	56	0.1172	0.5390	0.6824	0.4386	1.0619	0.2238
2015	424	59	0.1392	0.7820	0.8797	0.5721	1.3528	0.2177
2016	521	79	0.1516	0.7119	0.7757	0.5280	1.1396	0.1941
2017	490	51	0.1041	0.6343	0.6535	0.4087	1.0448	0.2379
2018	461	54	0.1169	0.7823	0.7492	0.4764	1.1784	0.2294
2019	452	79	0.1748	1.1358	1.5201	1.0636	2.1727	0.1800
2020	404	88	0.2178	1.4223	1.3100	0.9251	1.8549	0.1752
2021	473	47	0.0987	0.6127	0.6645	0.4104	1.0758	0.2445
2022	386	69	0.1799	1.2033	1.3068	0.8618	1.9817	0.2105
2023	450	86	0.1911	1.1915	1.3634	0.9633	1.9297	0.1750
2024	461	85	0.1844	1.1069	1.1348	0.7938	1.6224	0.1802

Figure 1. Fork lengths (cm) of sandbar sharks (≥ 80 cm FL) caught during the SEAMAP LL ATL surveys from 2007-2024 and a bubble plot showing size by sex over time for all sizes.



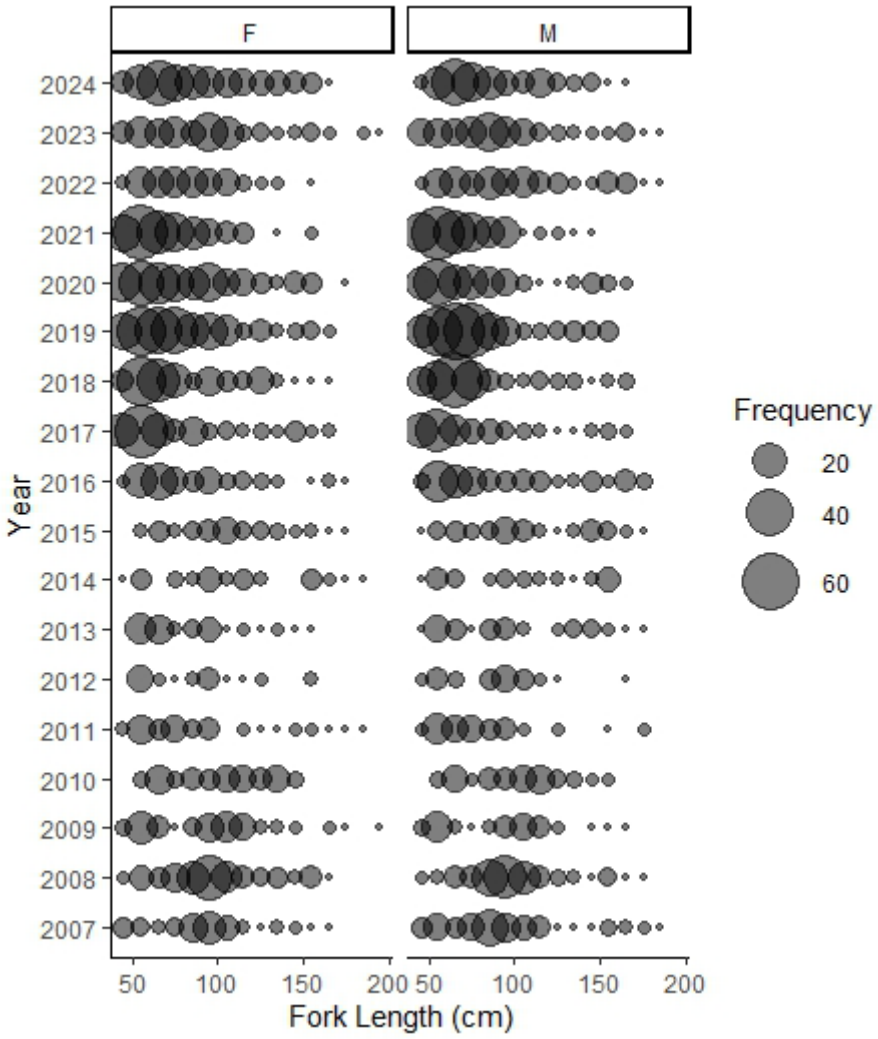


Figure 2. Histograms of set catch data by year showing the zero-inflated distribution over time

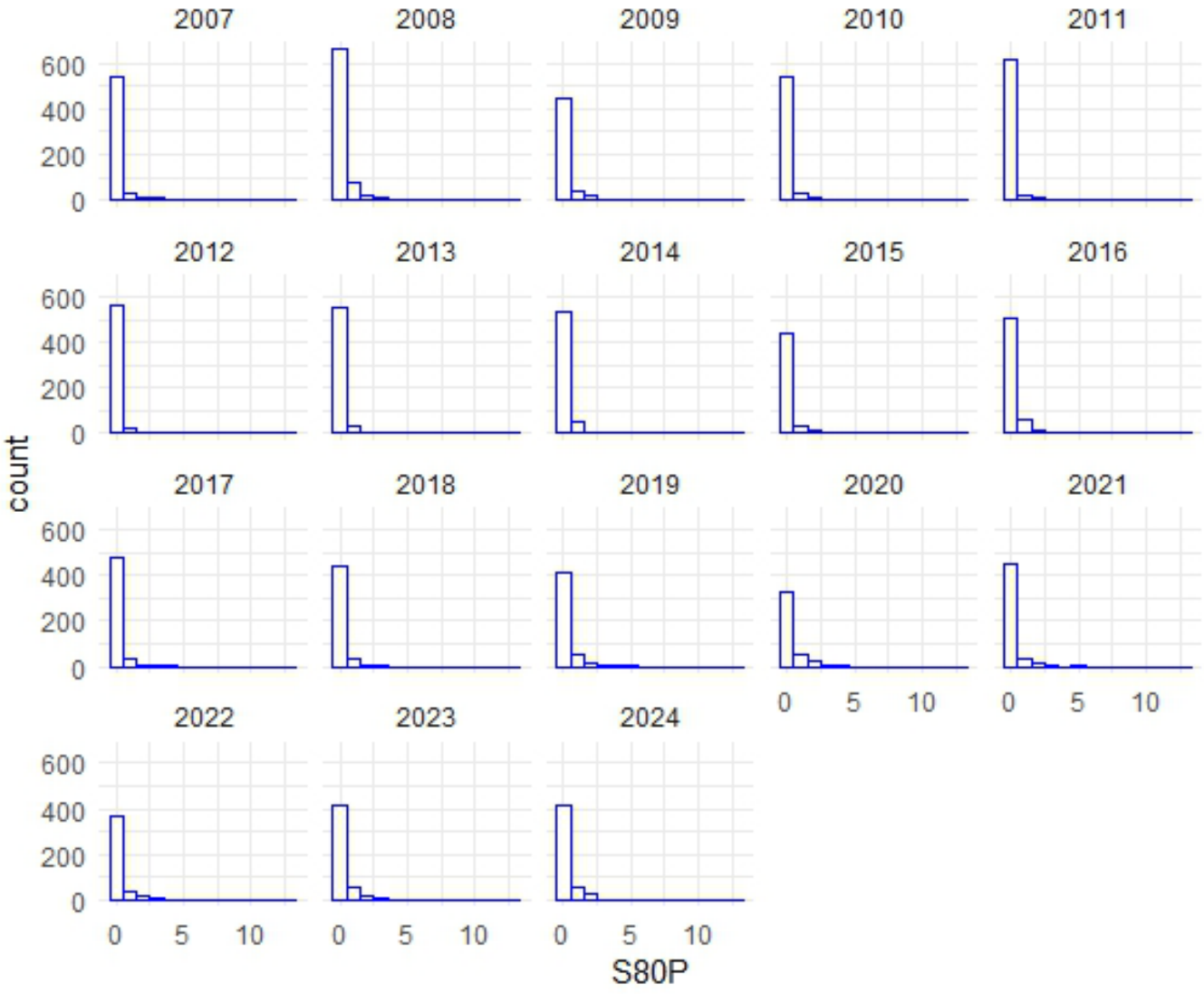
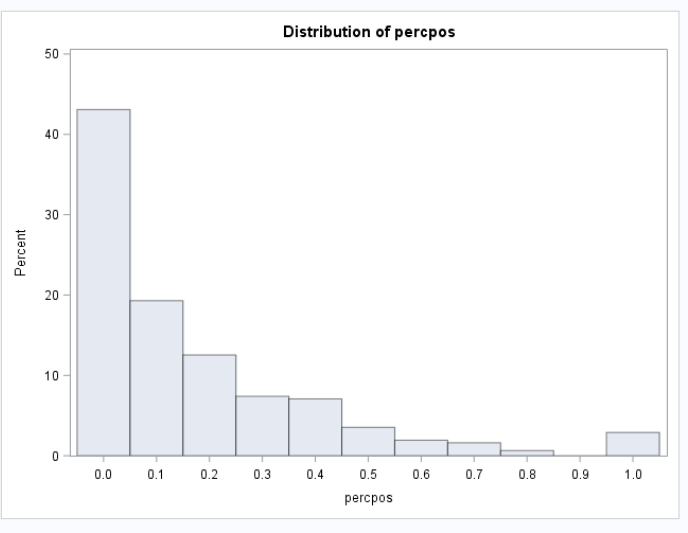
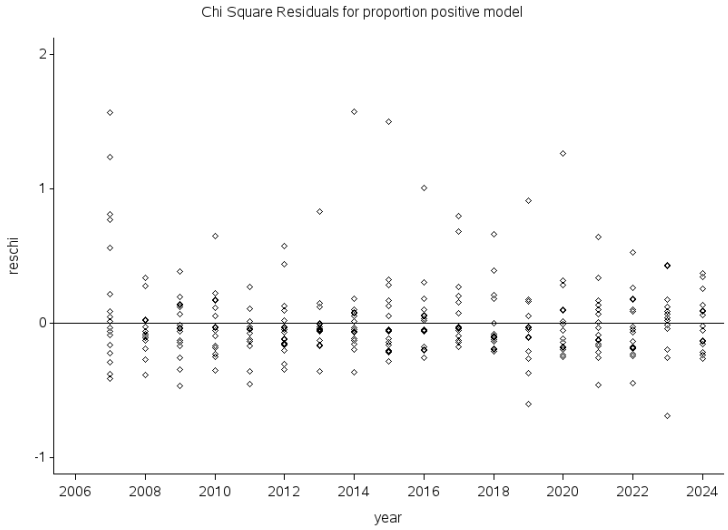
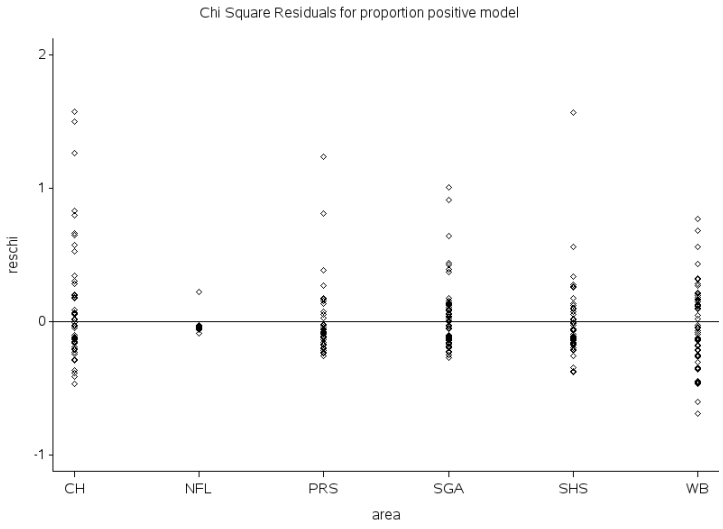
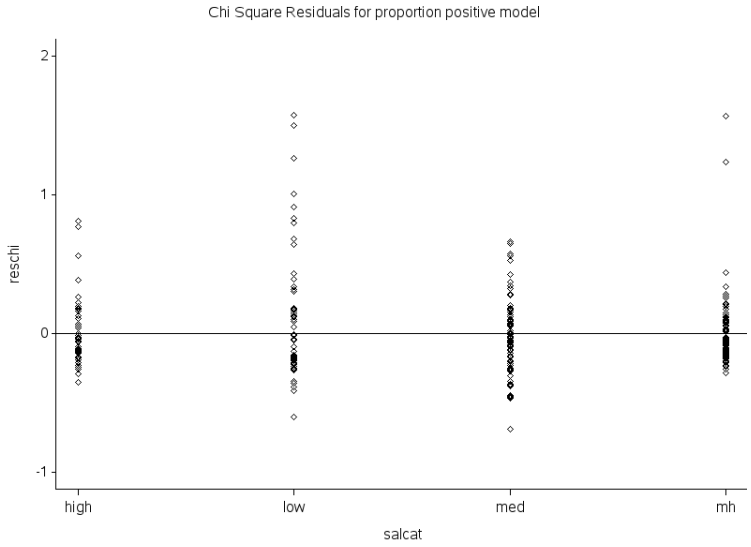


Figure 3. Original Diagnostic plots for the **binomial component** of the SEAMAP LL ATL catch rate model for sandbar sharks (80+ cm FL) from **2007 to 2024**.









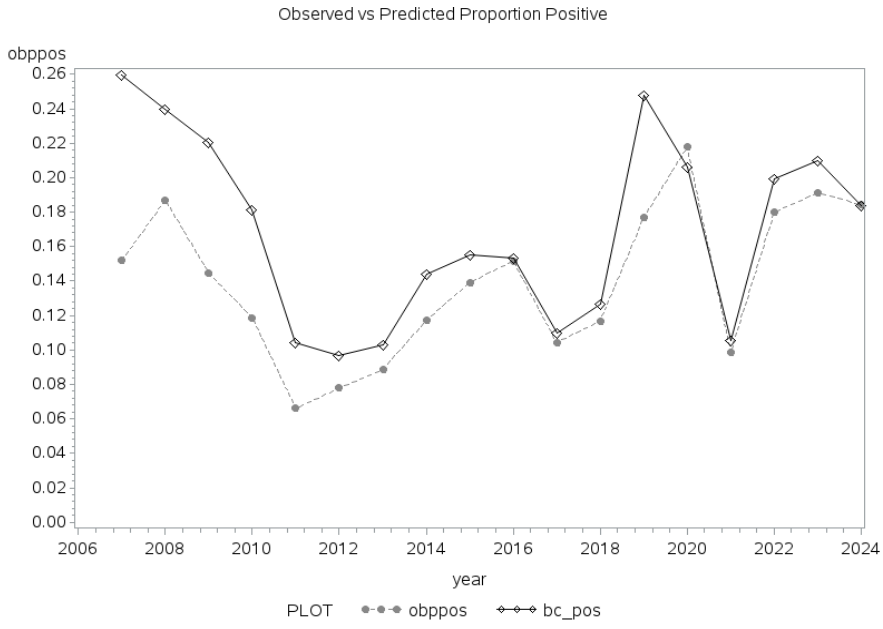
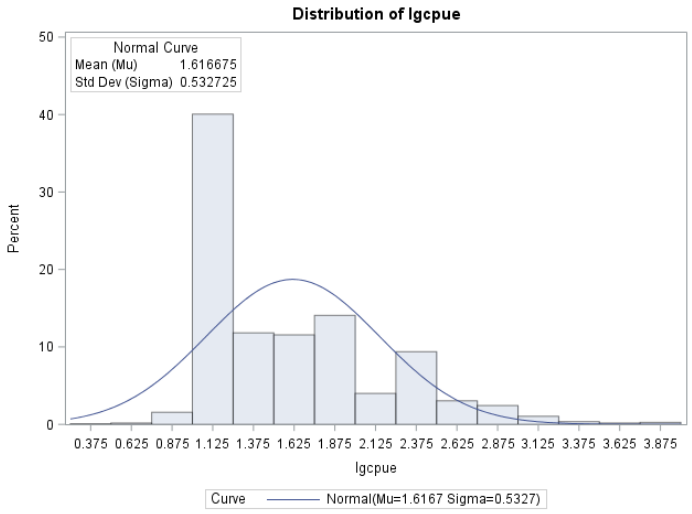
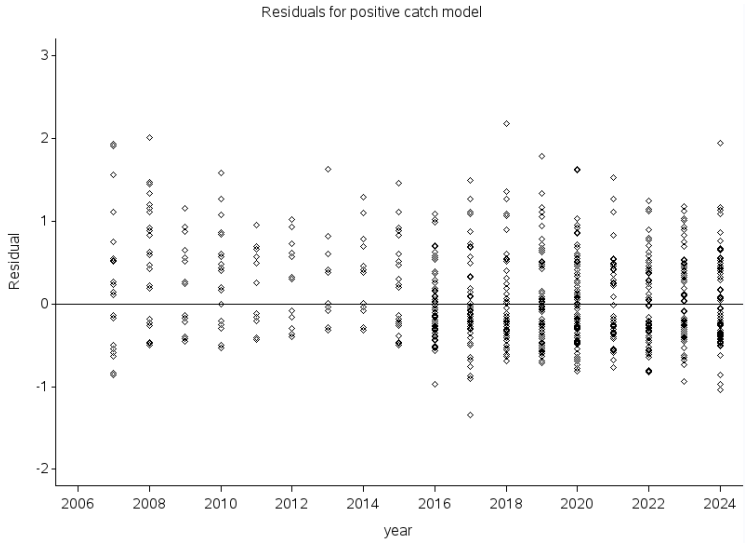
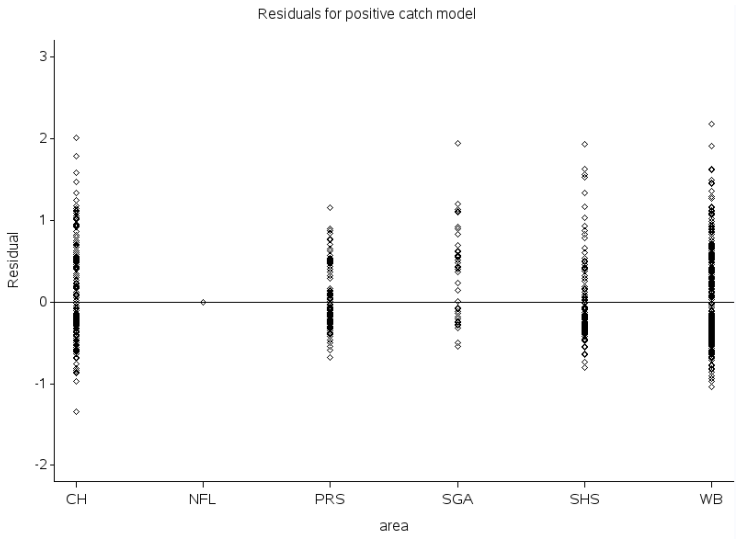
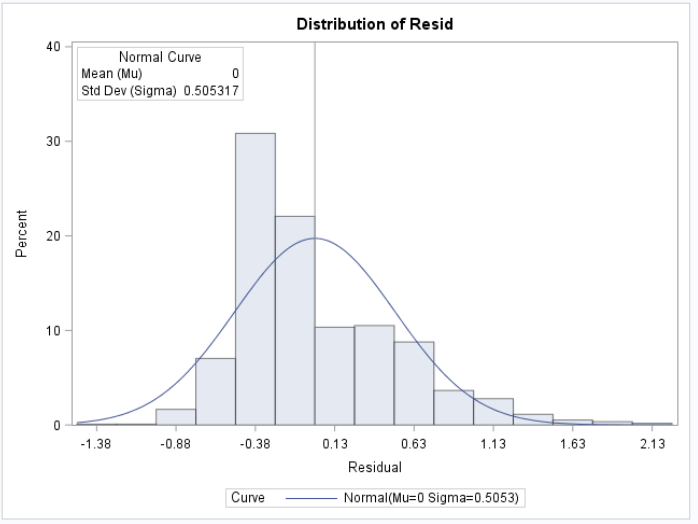


Figure 4. Diagnostic plots for the **lognormal component** of the SEAMAP LL ATL catch rate model for sandbar sharks (80+ cm FL)**.**









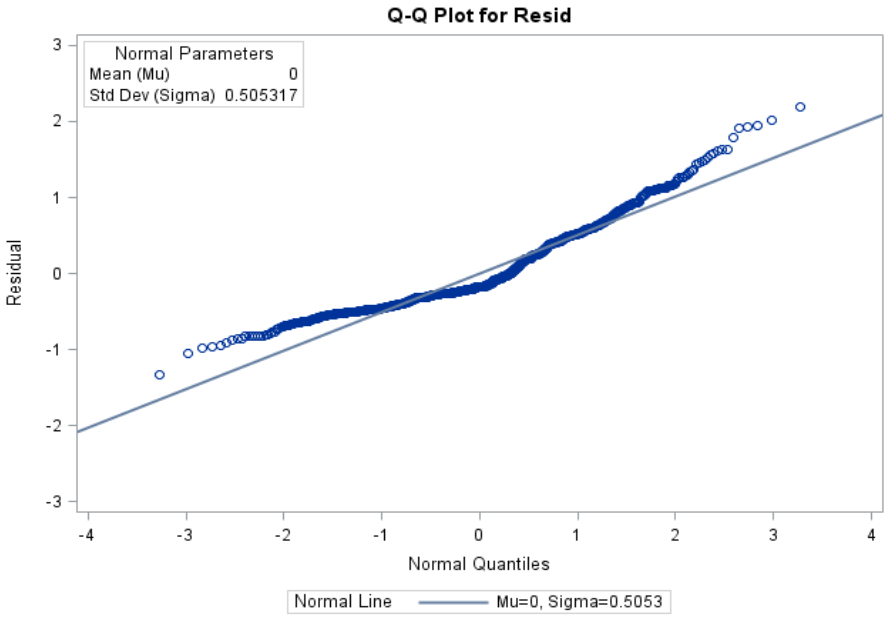


Figure 5. SEAMAP LL ATL index for sandbar shark (80+ cm FL) relative abundance (estcpue) with 95% confidence intervals (LCI0, UCI0) and overlayed with the nominal catch-per-unit-effort data. (obcpue)

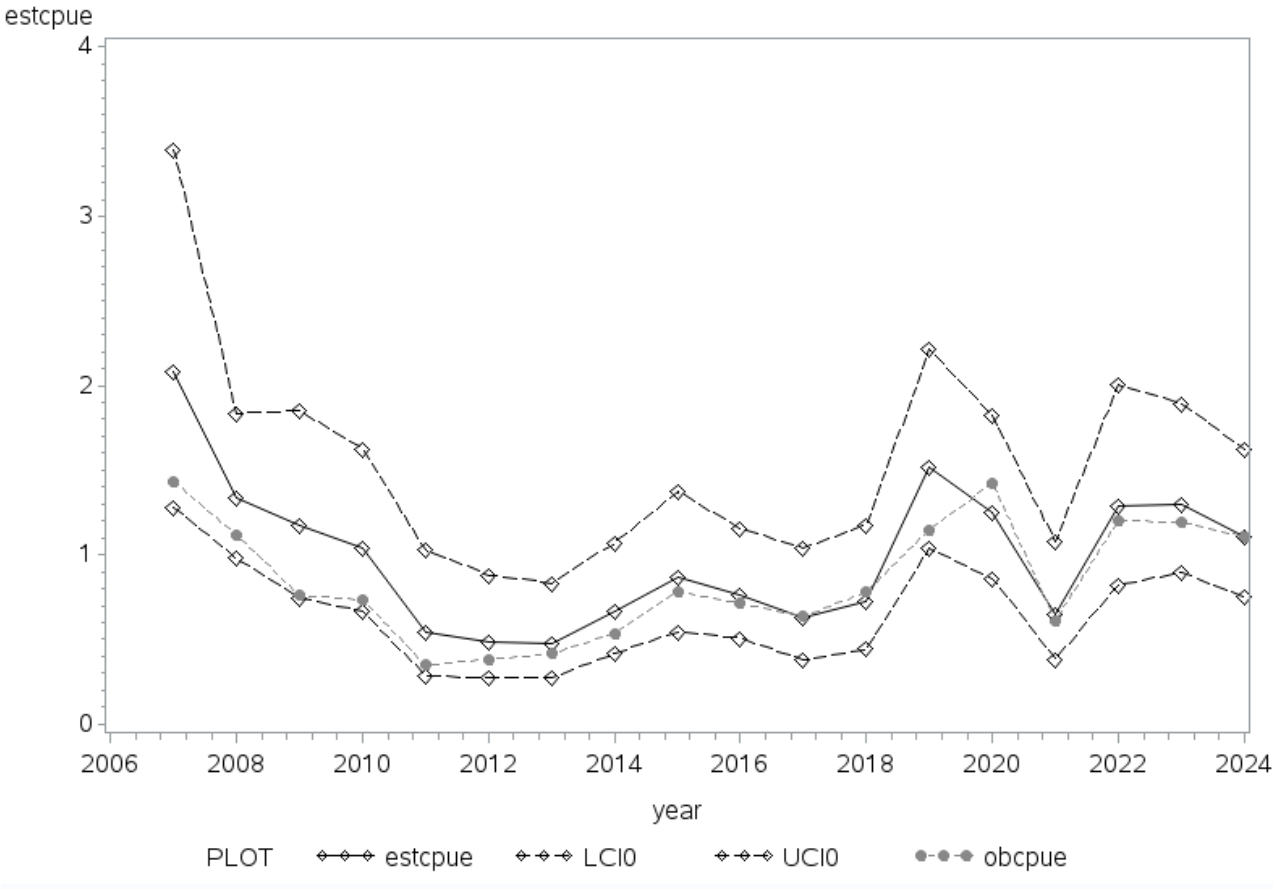


Figure 6. Retrospective analysis of the SEAMAP index **2007-2024**

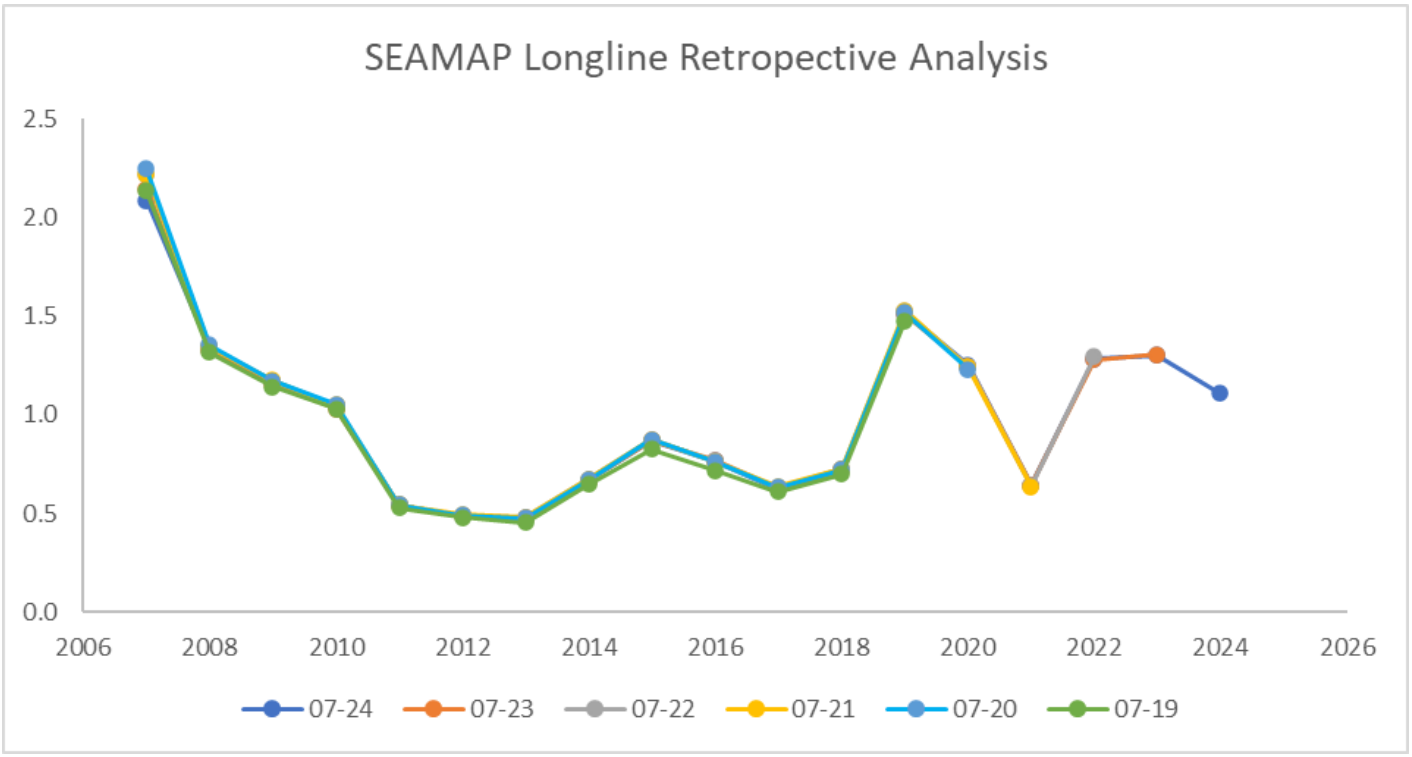
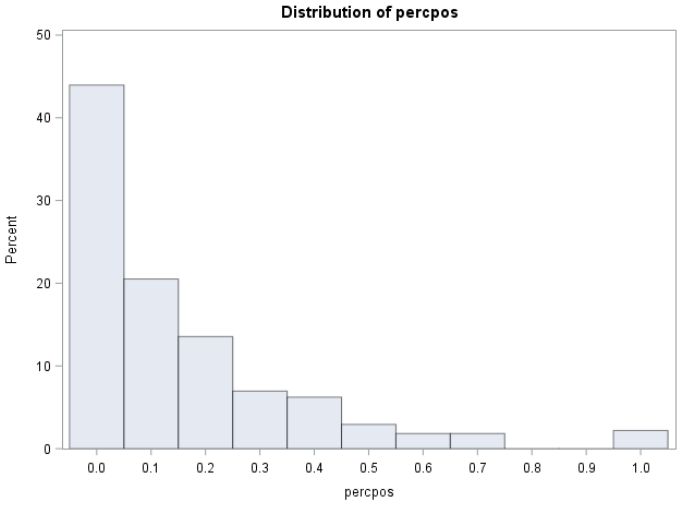
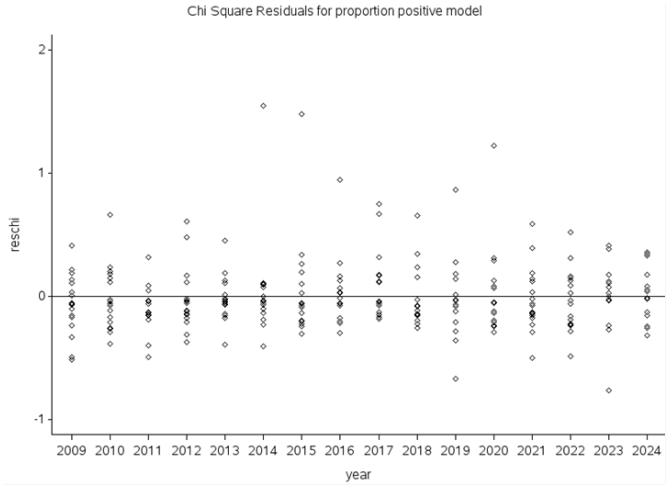
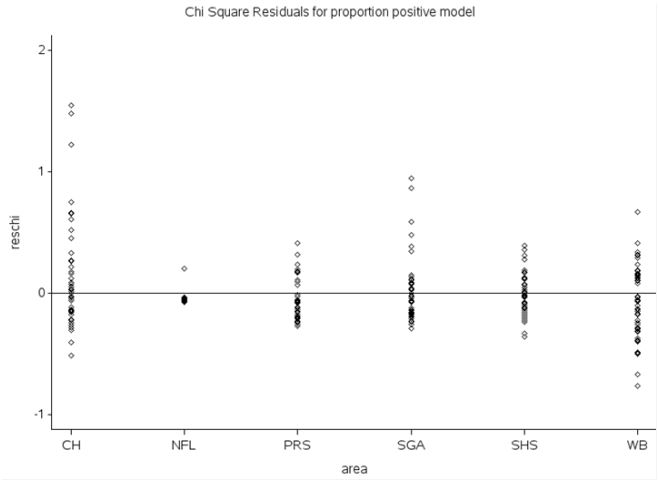
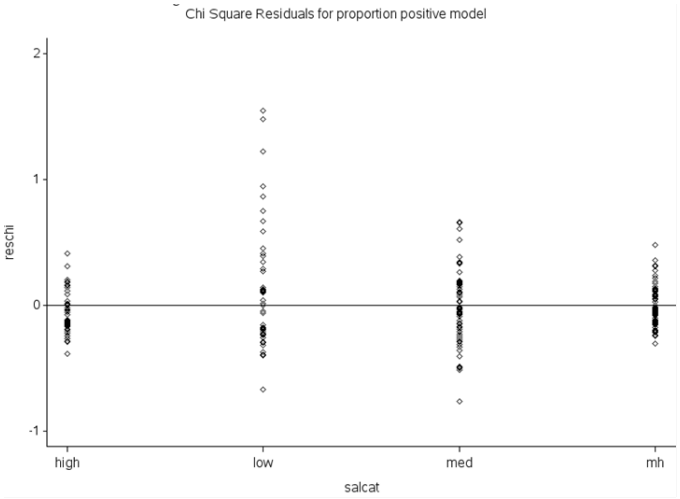


Figure 7. Original Diagnostic plots for the **binomial component** of the SEAMAP LL ATL catch rate model for sandbar sharks (80+ cm FL) from **2009 to 2024**.









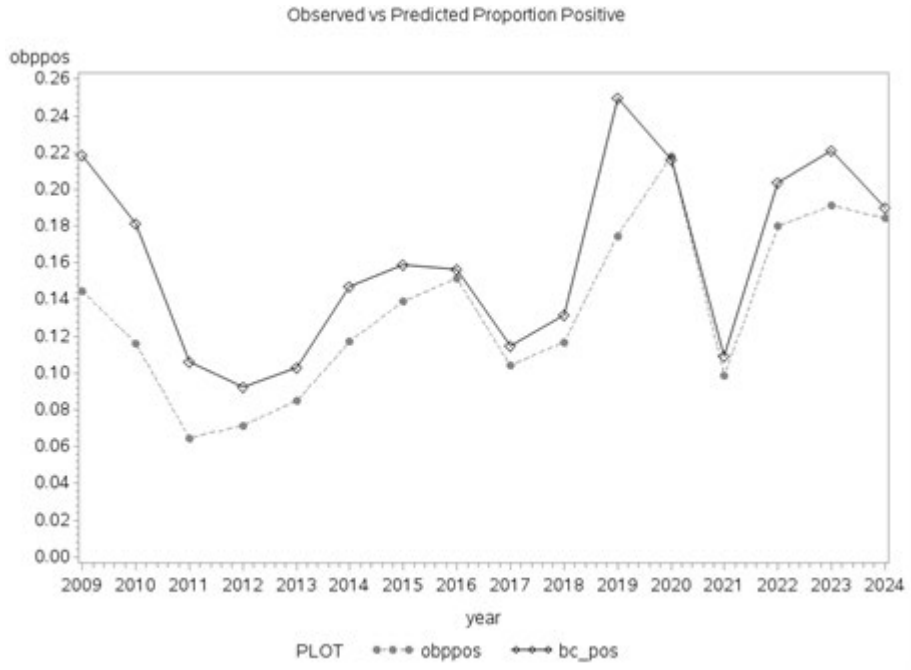
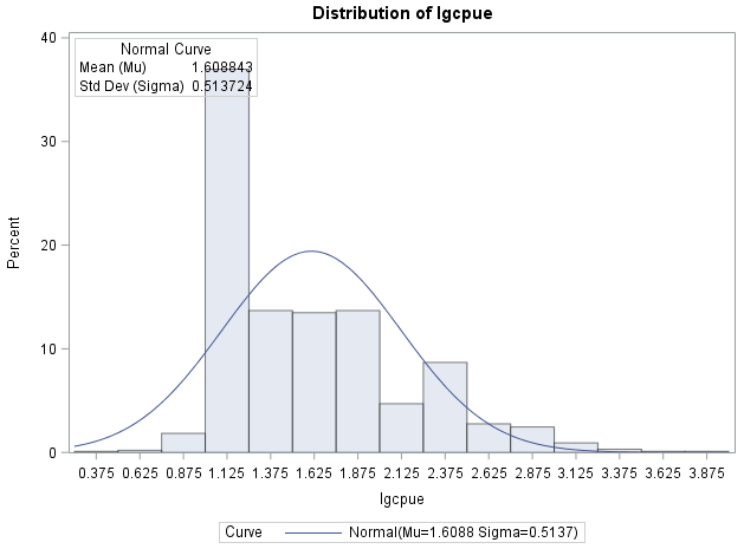
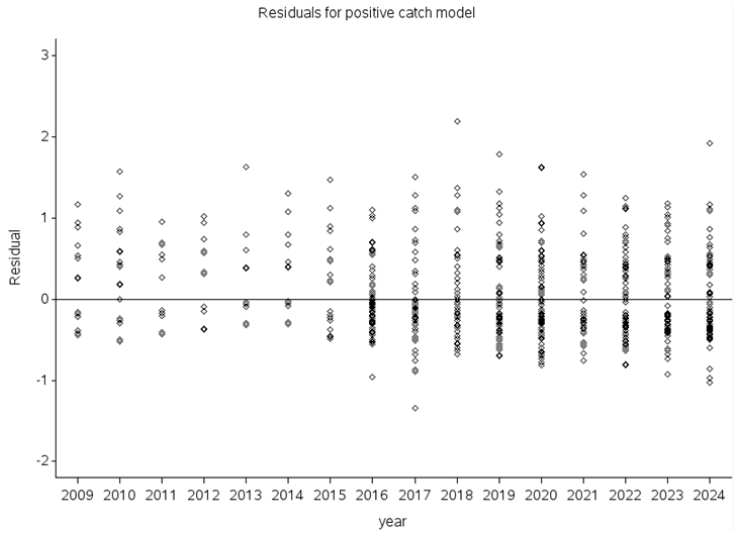
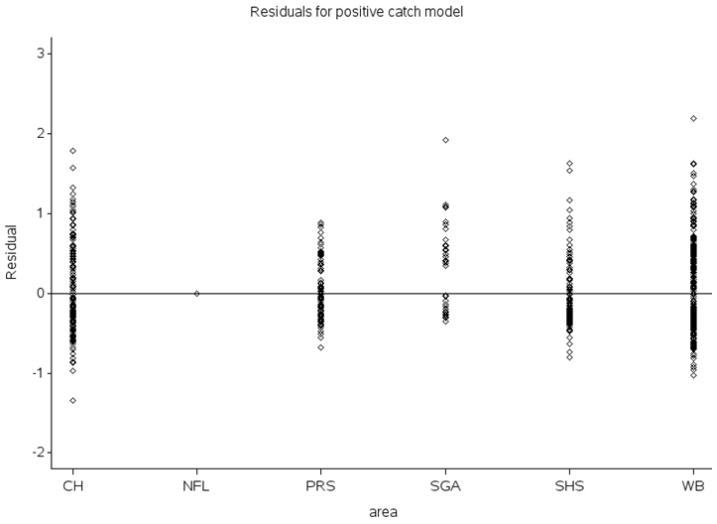
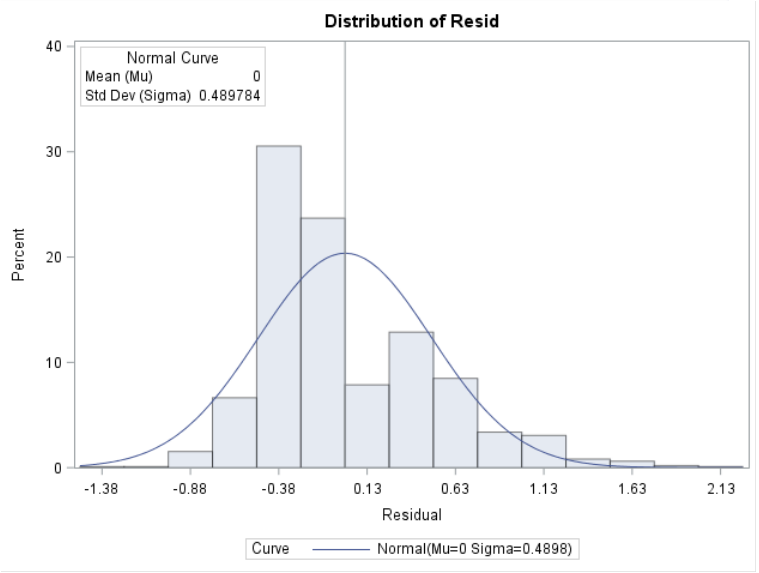


Figure 8. Diagnostic plots for the **lognormal component** of the SEAMAP LL ATL catch rate model for sandbar sharks from **2009 to 2024**.









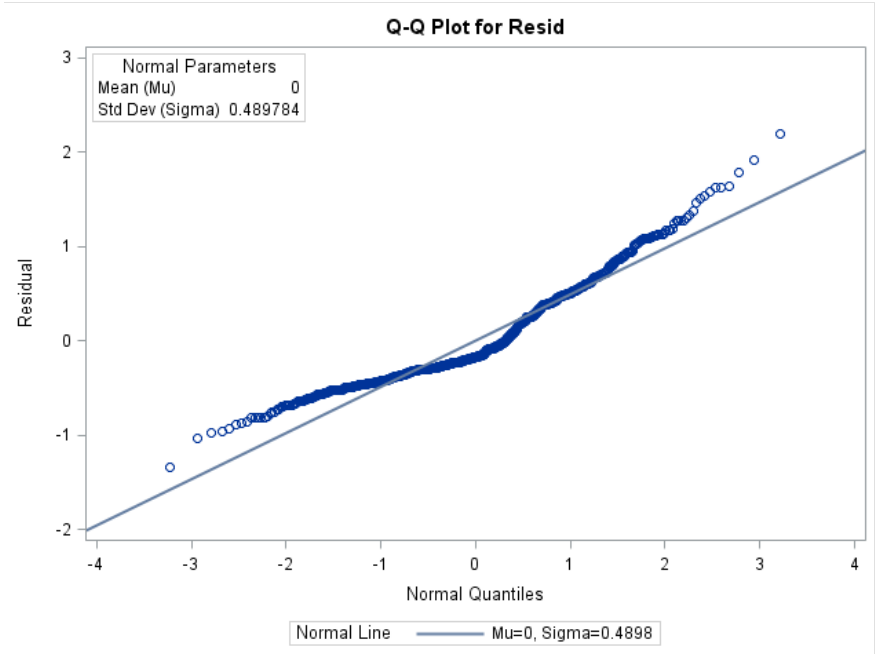


Figure 9. SEAMAP LL ATL index for sandbar shark (80+ cm FL) relative abundance (estcpue) with 95% confidence intervals (LCI0, UCI0) and overlayed with the nominal catch-per-unit-effort data. (obcpue)

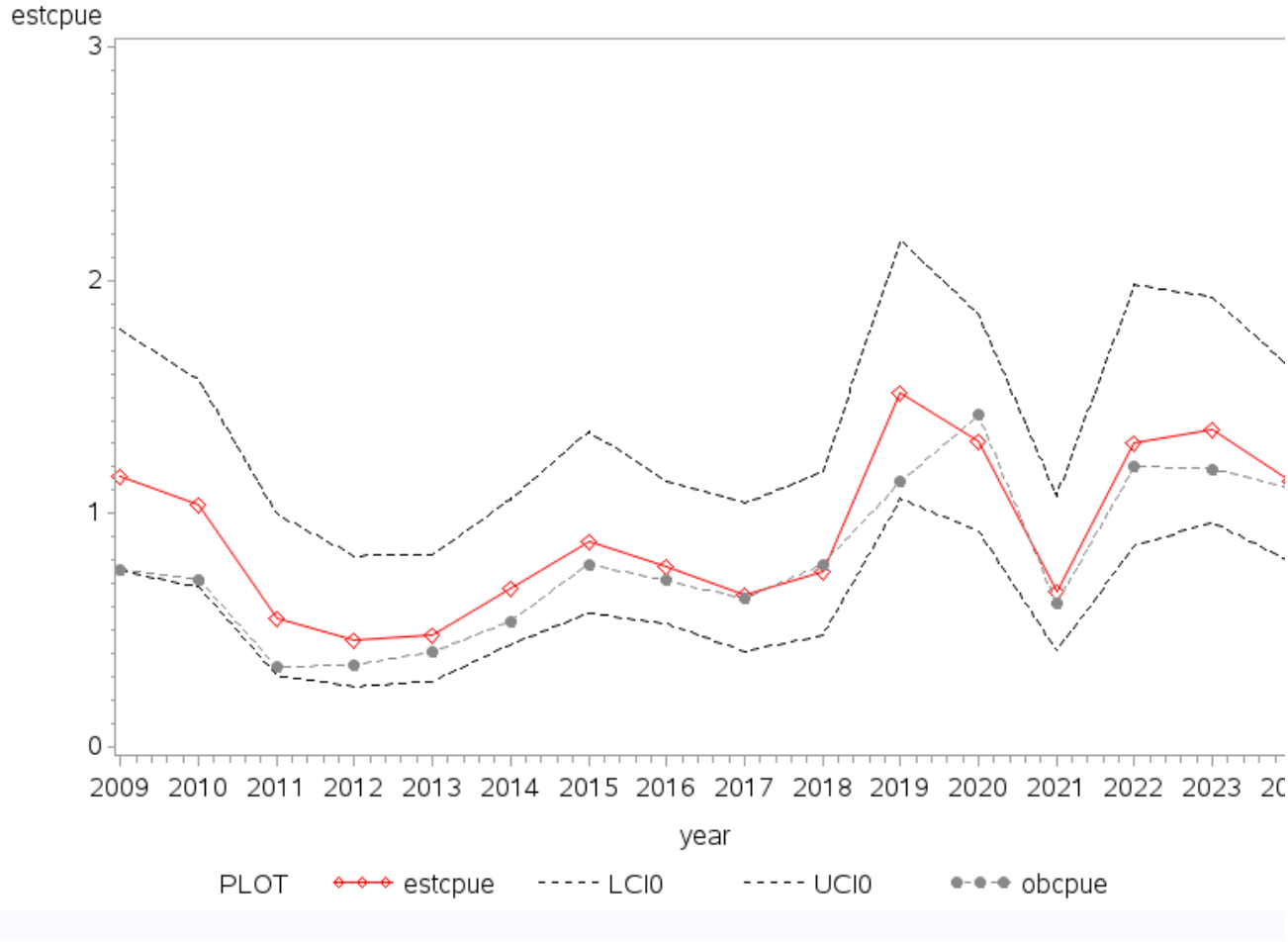


Figure 10. Retrospective analysis of the SEAMAP index **2009-2024**