Standardized catch rates of bonnethead (*Sphyrna tiburo*) from the South Carolina Department of Natural Resources trammel net survey

Bryan S. Frazier and Camilla T. McCandless

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SEDAR 34 DATA WORKSHOP DOCUMENT

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Bryan S. Frazier[1], Camilla T. McCandless[2]

[1]South Carolina Department of Natural Resources, 217 Ft. Johnson Rd. Charleston, SC 29412, USA (email:frazierb@dnr.sc.gov)

[2]NOAA/NMFS/NEFSC Apex Predators Investigation, 28 Tarzwell Dr. Narragansett, RI 02882, USA (email: cami.mccandless@noaa.gov)

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Summary

The trammel net survey has been conducted since 1991 and is currently an ongoing program. It uses a stratified random sampling protocol from seven different South Carolina estuaries (as strata) with individual sampling sites chosen at random within each estuarine area on a monthly basis. Sampling occurs year round, and all strata are sampled every month. The trammel net program was designed to monitor important recreational finfish species (red drum, spotted seatrout, and flounder), however bonnethead are frequently encountered. Data from this survey were used to look at trends in relative abundance of bonnethead in South Carolina estuarine waters. Bonnethead catch per unit effort (CPUE) in number of sharks per net hour were examined by year. The CPUE was standardized using the Lo et al (2002) method which models the proportion of positive sets separately from the positive catch. Nominal and standardized CPUE results from this survey indicate an increase in bonnethead relative abundance across the survey years.

Sampling Methods

The trammel net is a 184 m long by 2.1 m deep with 177 mm outer mesh and 63 mm inner mesh. The net is used to encircle a 150 m length of shoreline. An anchor is thrown at a set point in the shoreline, and rapidly deployed by a 6 meter custom trammel net boat in an encircling pattern, when all the net has been deployed; a second anchor is deployed on the shoreline, closing off the area inside the net. Once the net is set, the boat enters the area encircled by the net, and disturbs the water driving fish into the net. The gear is then immediately retrieved removing all catch. All bonnetheads captured are measured to stretch total length and sex. Set time is considered time from initial anchor set, to full gear pickup. Seven different estuary systems are sampled for each month with longevity of sampling ranging as new strata were added to the survey (Figure 1). Charleston Harbor, Cape Romain, and the Wando River data sets had collections from January 1991 to December 2007. The Ashley River was sampled from 1992 through 2007, the ACE Basin was sampled from 1994 through 2007, the Cooper River was sampled from 1999 through 2001, and Winyah Bay was sampled from 2001 to 2007.

Data Analysis

Catch per unit effort (CPUE) in number of sharks per net hour were used to examine bonnethead relative abundance for SCDNR trammel net surveys. The CPUEs were standardized using the Lo et al. (2002) method which models the proportion of positive sets separately from the positive catch. For the purposes of this SEDAR process, male bonnetheads smaller than 37 cm fork length (FL) and female bonnetheads smaller than 36 cm FL were considered to be young-of the-year sharks and excluded from analyses of age 1+ sharks. A subset of the total trammel net sets were used for catch analysis excluding sets with temperatures below 17degC, salinities below 15ppt, sets between December and March, and the years 1990-1993. No bonnetheads were caught during any of the excluded sets. Factors considered as potential influences on trammel net sets were: year (1994–2011), month (April-November), water temperature (<20degC, 20-24degC, 25-29, 30+degC), salinity (<20ppt, 20-24ppt, 25-29ppt, 30+ppt), depth (<1.0m, 1.0-1.9m, 2+m), and area (Ace Basin, Cape Romain Harbor, Charlestown Harbor, Lower Wando River, McClellanville Banks, and Winyah Bay). 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. 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

SC trammel net survey – age 1+ bonnetheads

A total of 1603 age 1+ bonnetheads were caught during 6896 trammel net sets from 1994 to 2011. The size range of bonnetheads caught by year is displayed in Figure 2. The proportion of sets with positive catch (at least one age 1+ bonnethead caught) was 23%. 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 3). 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.

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 SCDNR trammel net catch rate model for age 1+ bonnetheads. %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%	L	CHISQ	PR>CHI
null	3071	3221.3097	1.0489					
area	3066	2464.8767	0.8039	23.3578	23.3578	-2025.6796	756.43	<.0001
sal	3068	2770.4034	0.9030	13.9098		-2178.4430	450.91	<.0001
month	3064	2869.6174	0.9366	10.7065		-2228.0500	351.69	<.0001
temp	3068	2891.2295	0.9424	10.1535		-2238.8560	330.08	<.0001
year	3054	3063.4456	1.0031	4.3665		-2324.9640	157.86	<.0001
depth	3068	3207.8829	1.0456	0.3146		-2397.1827	13.43	0.0038
area +								
month	3059	2096.2339	0.6853	34.6649	11.3071	-1841.3582	368.64	<.0001
temp	3063	2125.2031	0.6938	33.8545	10.4967	-1855.8428	339.67	<.0001
year	3049	2308.8803	0.7573	27.8006	4.4427	-1947.6814	156.00	<.0001
sal	3063	2437.5836	0.7958	24.1300	0.7722	-2012.0331	27.29	<.0001
area + month								
year	3042	1919.2646	0.6309	39.8513	5.1864	-1752.8735	176.97	<.0001
temp	3056	2041.0119	0.6679	36.3238	1.6589	-1813.7472	55.22	<.0001
area + month + year								
temp	3039	1878.4193	0.6181	41.0716	1.2203	-1732.4509	40.85	<.0001

FINAL MODEL: area + month + year + temp

Akaike's information criterion	2544.9
Schwartz's Bayesian criterion	2767.9
(-2) Res Log likelihood	3464.9

Type 3 Test of Fixed Effects

	area	month	year	temp
Significance (Pr>Chi) of Type 3 test of fixed effects for each factor	<.0001	<.0001	<.0001	<.0001
DF	5	7	17	3
CHI SQUARE	779.89	95.86	162.59	40.85

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%	L	CHISQ	PR>CHI
null	767	290.5495	0.3646					
depth	794	276.7744	0.3486	4.3884	4.3884	-709.8095	38.76	<.0001
year	780	278.8791	0.3575	1.9473		-712.8322	32.71	0.0122
sal	795	286.6537	0.3606	1.0971		-724.2101	11.17	0.0108
temp	794	286.6281	0.3610	0.9874		-723.7677	10.84	0.0126
area	792	287.4266	0.3629	0.4663		-724.8777	8.62	0.1251
month	790	288.3425	0.3650	-0.1097		-726.1470	6.08	0.5299
depth +								
year	777	265.4588	0.3416	6.3083	1.9199	-639.1530	39.36	0.0103
sal	791	274.653	0.3472	4.7724		-706.7394	6.14	0.1050
temp	791	276.2908	0.3493	4.1964		-709.1118	1.40	0.7066

FINAL MODEL: depth + year

Akaike's information criterion	1430.3
Schwartz's Bayesian criterion	1533.3
(-2) Res Log likelihood	1278.3

Type 3 Test of Fixed Effects

	depth	year
Significance (Pr>Chi) of Type 3 test of fixed effects for each factor	<.0001	0.0103
DF	3	17
CHI SQUARE	39.36	33.31

Table 2. SCDNR trammel net bonnethead analysis number of model observations per year (obs n), number of positive model observations per year (obs pos), proportion of positive model observations per year (obs ppos), nominal cpue as sharks per net hour (obs cpue), resulting estimated cpue from the model (est cpue), the lower 95% confidence limit for the est cpue (LCI), the upper 95% confidence limit for the est cpue (UCI), and the coefficient of variation for the estimated cpue (CV).

year	n obs	obs pos	obs ppos	obs cpue	est cpue	LCI	UCI	CV
1994	181	10	0.0552	0.0994	0.2636	0.1208	0.5750	0.4054
1995	215	11	0.0512	0.1653	0.4315	0.2038	0.9135	0.3886
1996	202	10	0.0495	0.1246	0.3654	0.1664	0.8023	0.4090
1997	308	17	0.0552	0.1998	0.3355	0.1808	0.6226	0.3166
1998	358	20	0.0559	0.1601	0.2889	0.1639	0.5091	0.2891
1999	388	36	0.0928	0.3726	0.6231	0.4086	0.9500	0.2133
2000	363	24	0.0661	0.3014	0.3695	0.2189	0.6237	0.2663
2001	383	52	0.1358	0.4732	0.7484	0.5285	1.0598	0.1753
2002	386	72	0.1865	0.7224	1.1156	0.8372	1.4865	0.1443
2003	401	65	0.1621	0.6229	1.1600	0.8580	1.5683	0.1516
2004	374	45	0.1203	0.4255	0.7552	0.5192	1.0985	0.1890
2005	427	47	0.1101	0.4432	0.8321	0.5720	1.2105	0.1891
2006	368	53	0.1440	0.5852	0.9613	0.6848	1.3495	0.1708
2007	429	78	0.1818	0.7185	1.3964	1.0685	1.8250	0.1344
2008	390	81	0.2072	0.8102	1.4024	1.0759	1.8279	0.1331
2009	408	82	0.2010	0.8982	1.6824	1.3014	2.1750	0.1289
2010	397	56	0.1411	0.5831	1.0293	0.7392	1.4334	0.1667
2011	425	49	0.1153	0.5075	0.9041	0.6347	1.2878	0.1783

Figure 1. Sample area of South Carolina trammel net survey (in red). Eight strata are present, however Port Royal Sound (bottom left) is excluded from analysis.

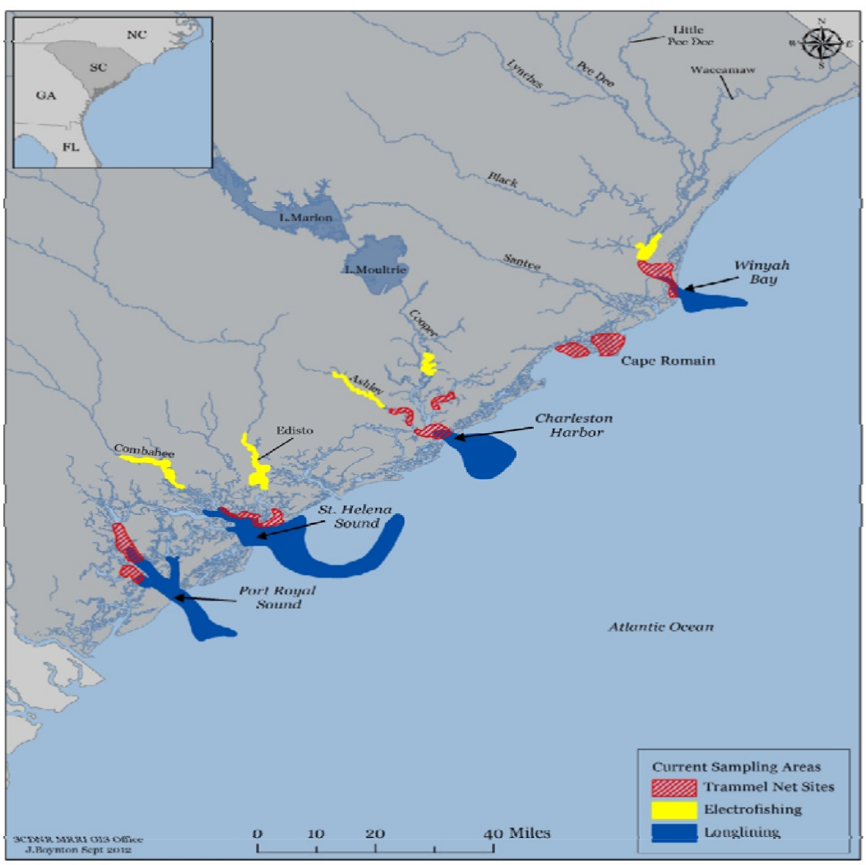


Figure 2. Total lengths (cm) of bonnetheads caught during the SCDNR trammel net survey from 1994-2011.

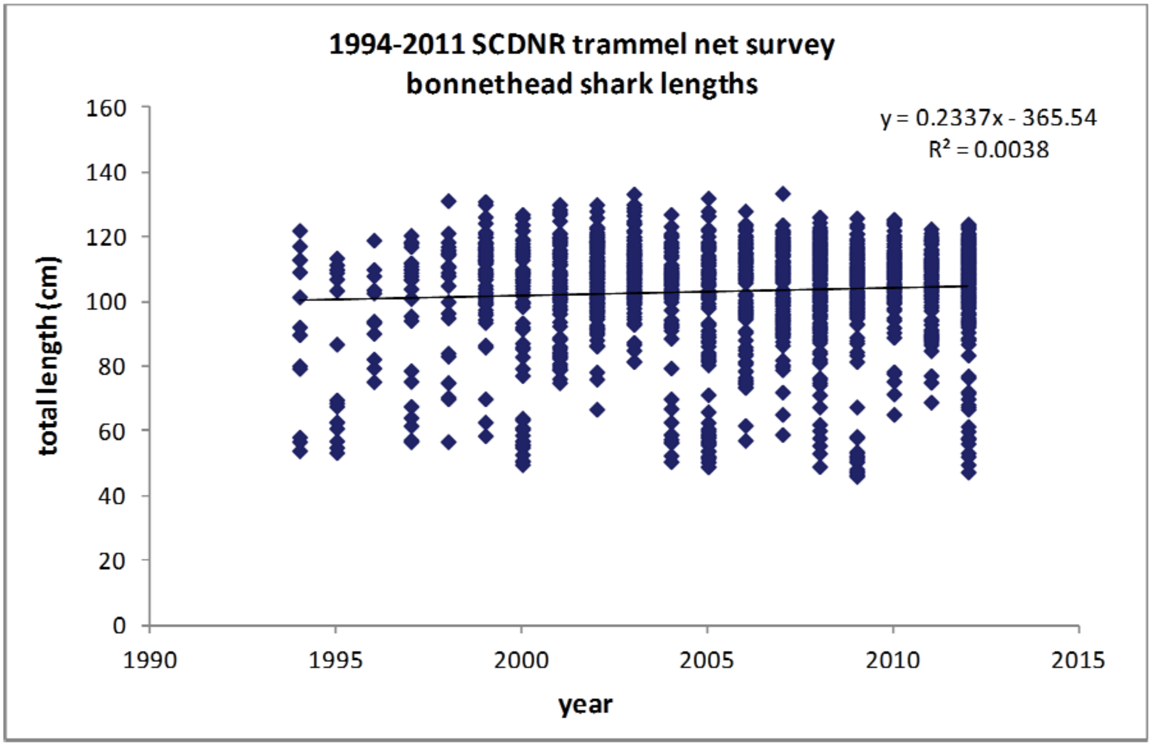


Figure 3a. SCDNR-TN age 1+ bonnethead model diagnostic plots for the binomial component.

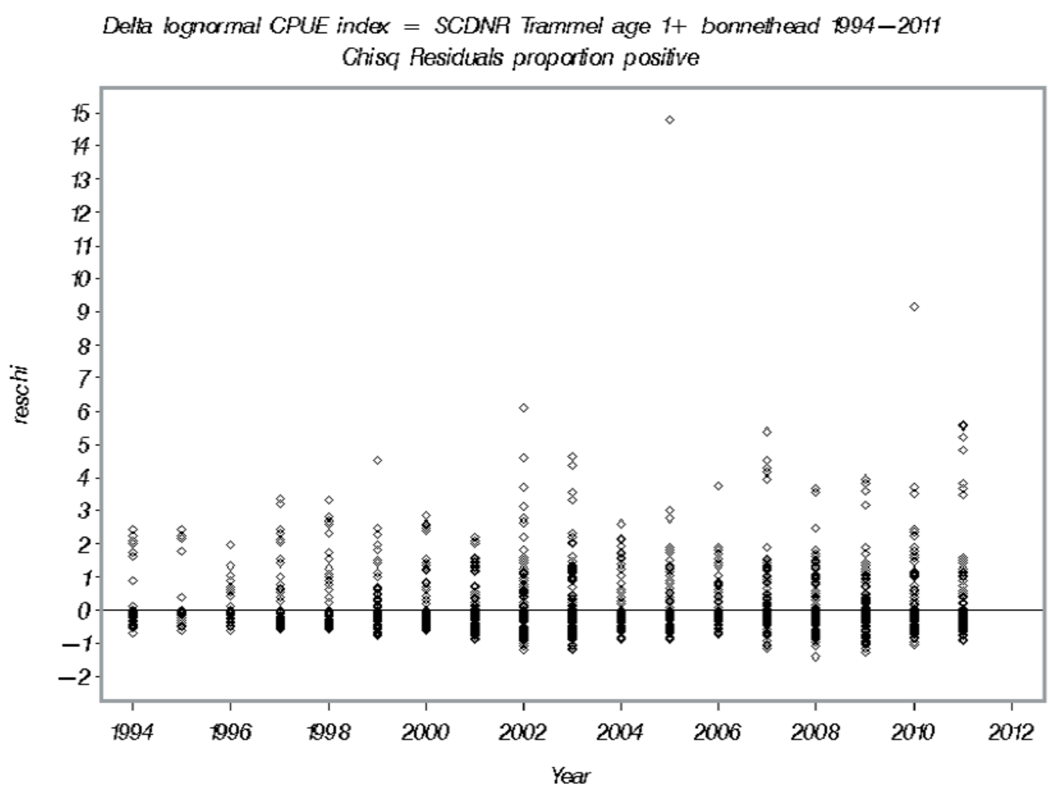
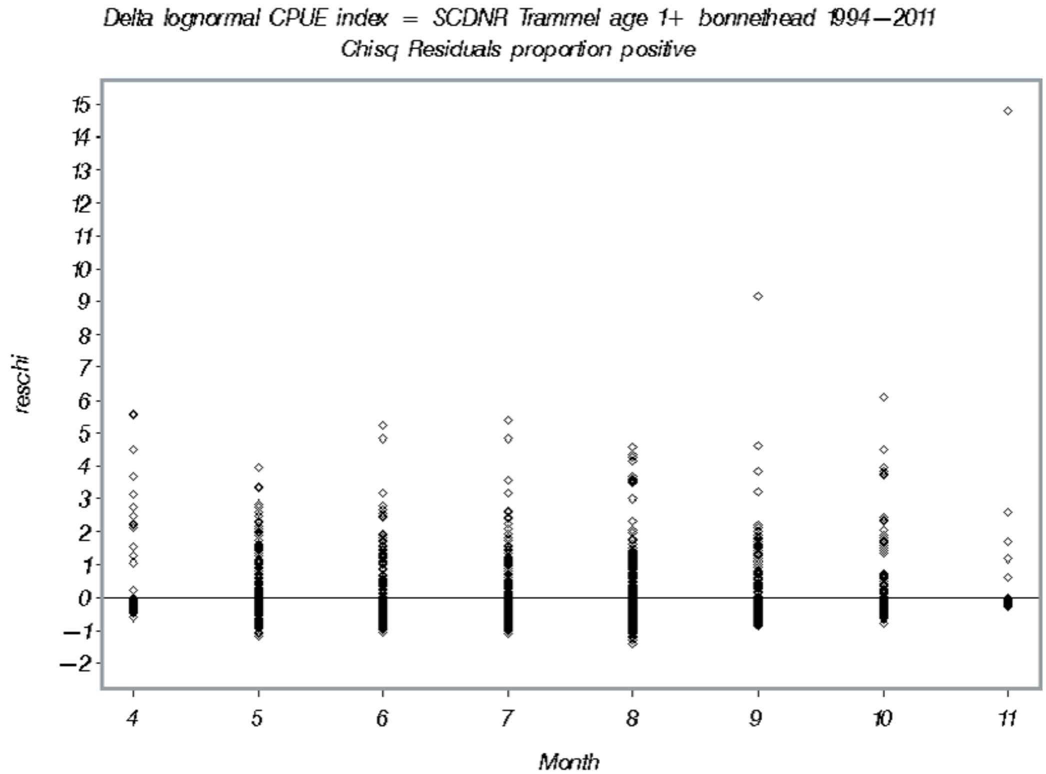


Figure 3a continued. SCDNR-TN age 1+ bonnethead model diagnostic plots for the binomial component.



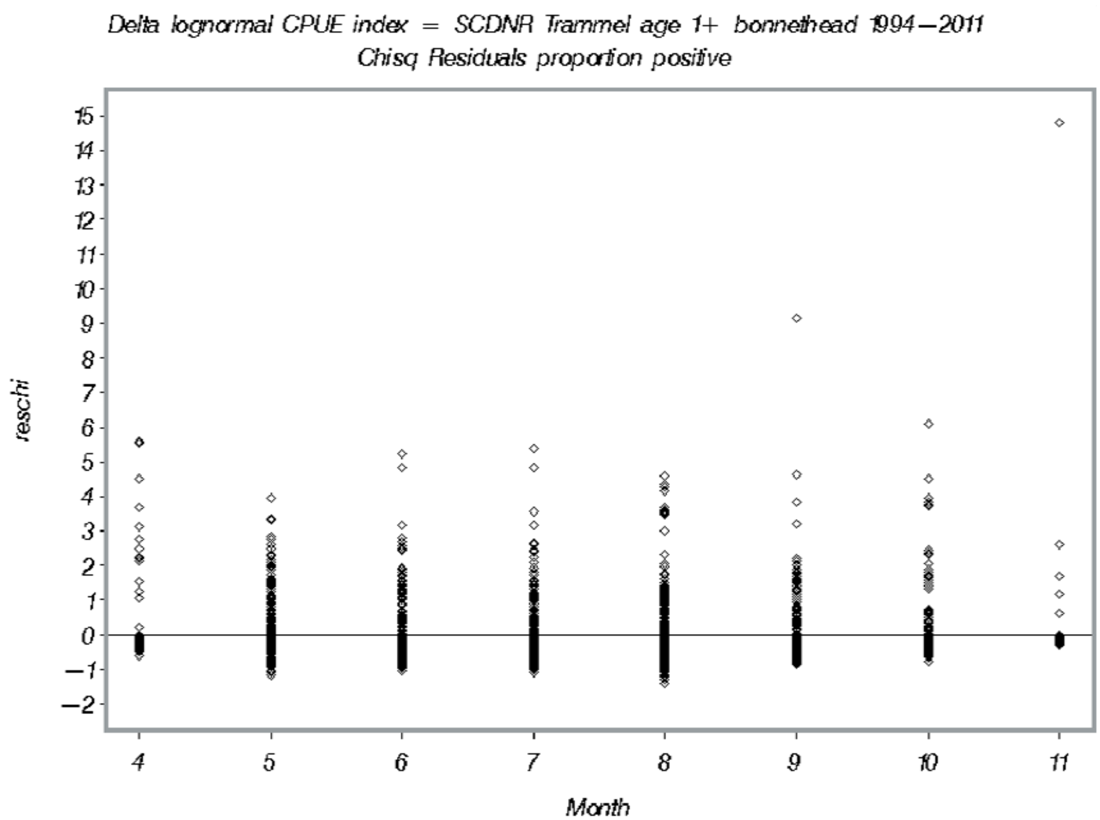
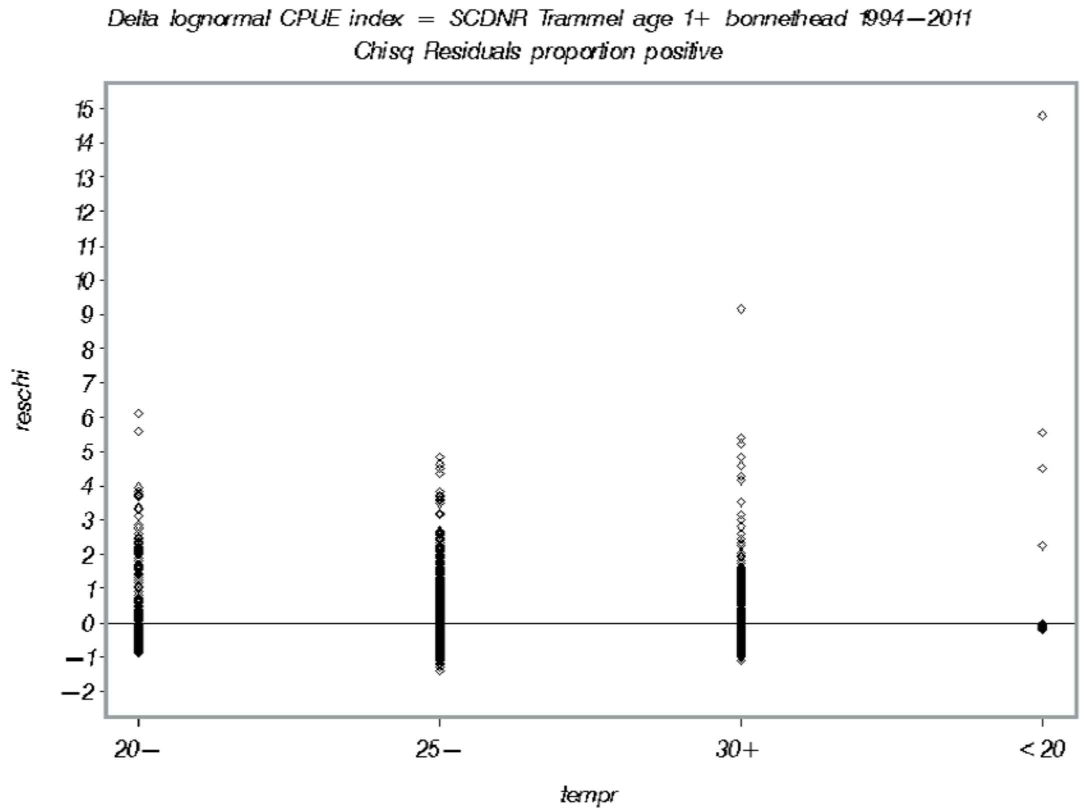


Figure 3a continued. SCDNR-TN age 1+ bonnethead model diagnostic plots for the binomial component.



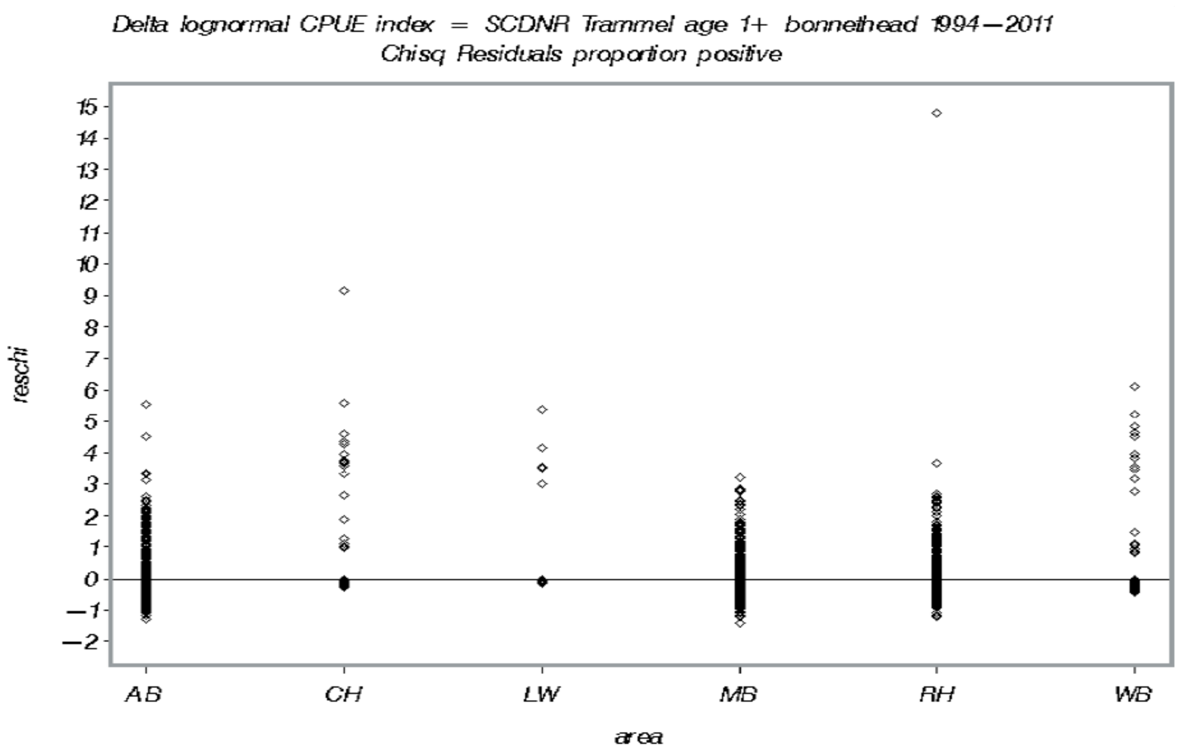


Figure 3a continued. SCDNR-TN age 1+ bonnethead model diagnostic plots for the binomial component.

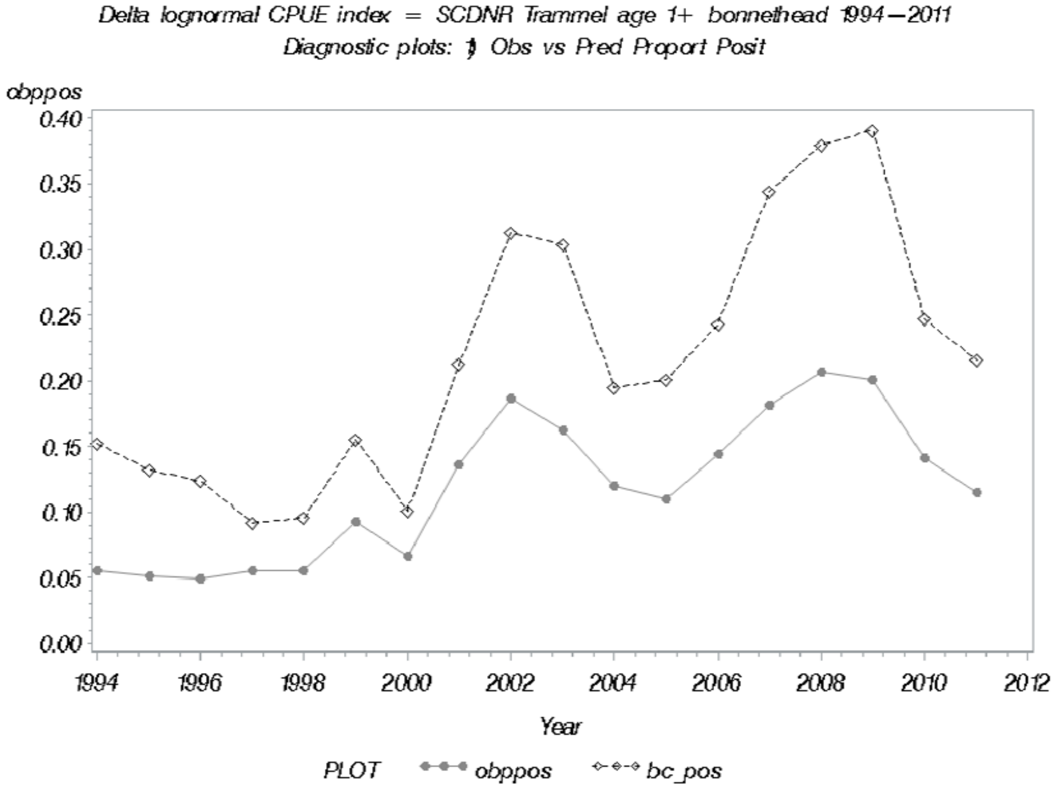


Figure 3b. SCDNR-TN age 1+ bonnethead model diagnostic plots for the lognormal component.

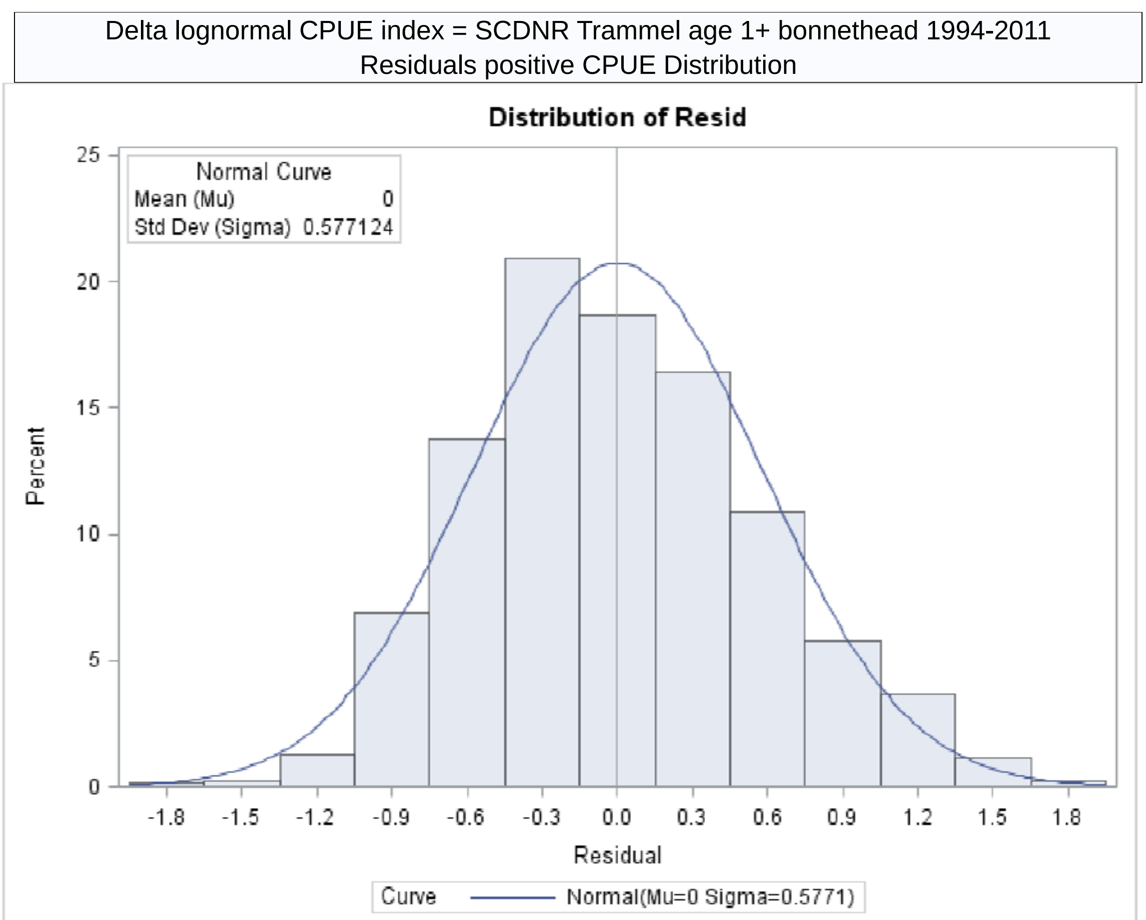
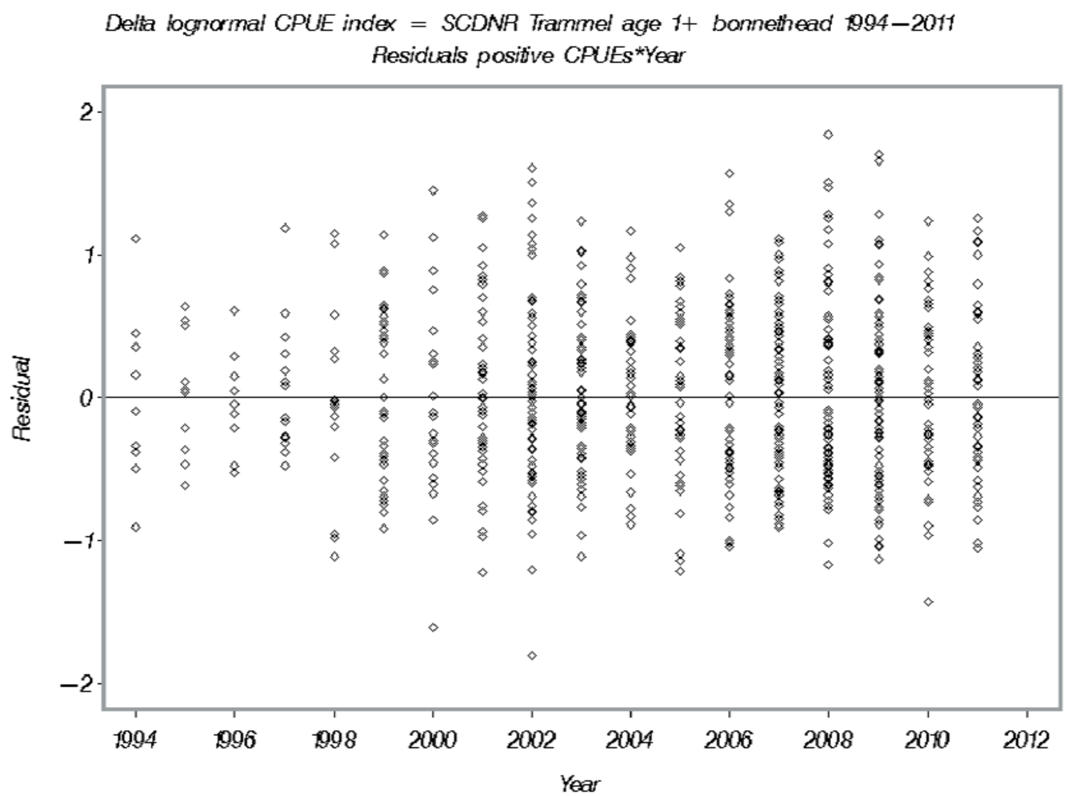


Figure 3b continued. SCDNR-TN age 1+ bonnethead model diagnostic plots for the lognormal component.



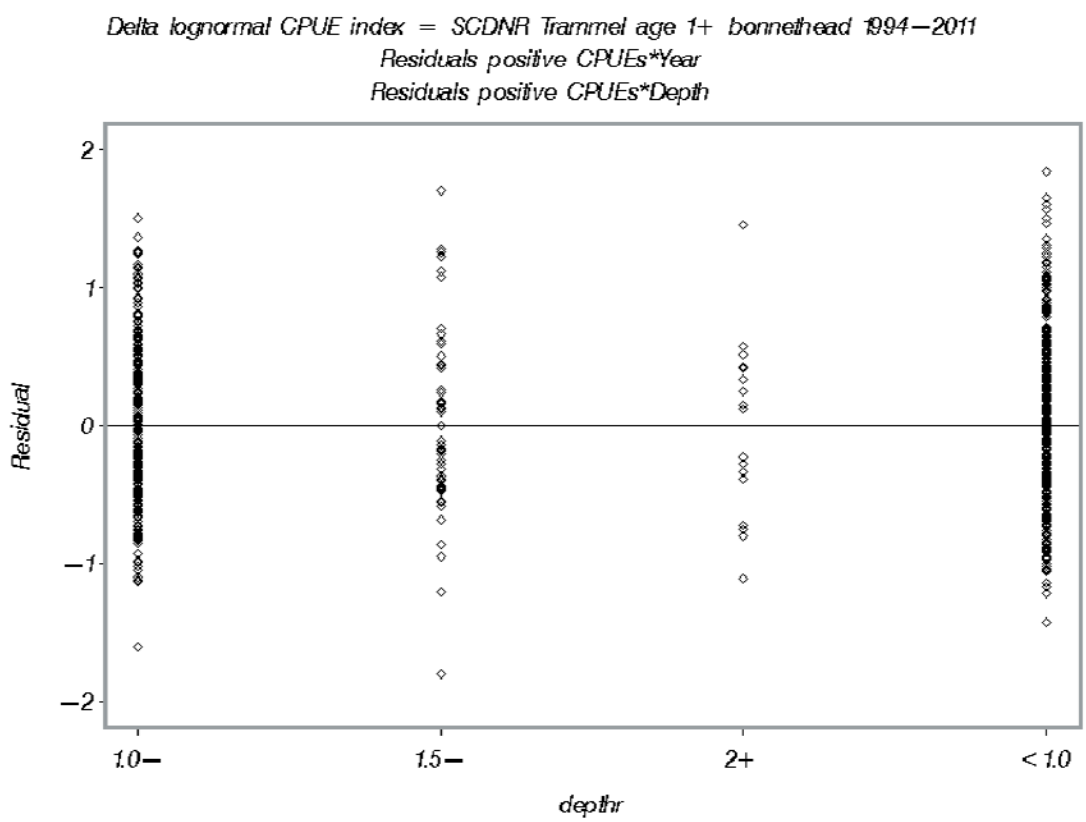


Figure 3b continued. SCDNR-TN age 1+ bonnethead model diagnostic plots for the lognormal component.

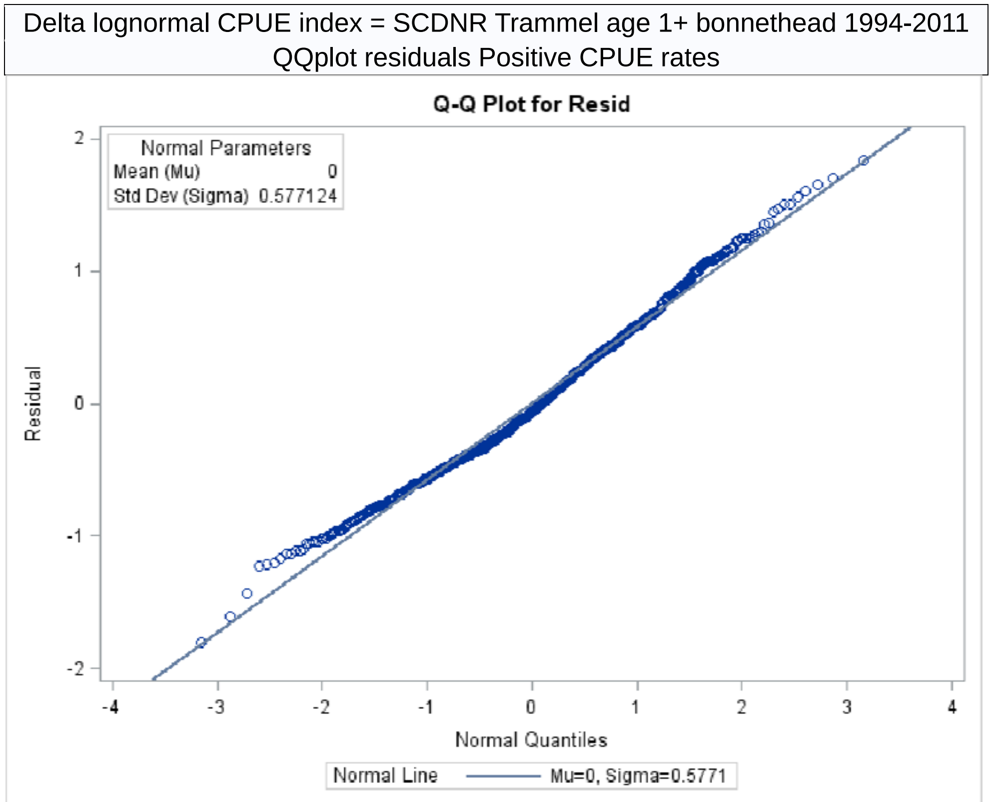


Figure 4. SCDNR-TN age 1+ bonnethead nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCL0, UCL0).