Standardized indices of abundance for Smooth Dogfish, *Mustelus canis*, from the University of North Carolina shark longline survey south of Shakleford Banks

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SEDAR 39 DATA WORKSHOP DOCUMENT

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Summary

This document details the smooth dogfish catch from April-November, 1972-2013, at two fixed stations in Onslow Bay south of Shackleford Banks, North Carolina. Catch per unit effort (CPUE) by set in number of sharks per number of set hooks were examined by year. The CPUE was standardized using a two-step delta-lognormal approach that models the proportion of positive catch with a binomial error distribution separately from the positive catch, which is modeled using a lognormal distribution. There were no smooth dogfish catches during the last two years of the time series. The majority of catches occurred during April and early May (82%), which were not consistently sampled across years due to weather and logistical constraints. The standardized relative abundance for smooth dogfish shows an overall slight decreasing trend throughout the time series with peaks in abundance in 2005 and 2010.

Introduction

In North Carolina waters, information about sharks was limited prior to 1972. This led to the establishment of a bi-weekly longline survey (April-November, 1972-2013) conducted at two fixed stations south of Shackleford Banks in Onslow Bay, North Carolina by the University of North Carolina (UNC), Institute of Marine Sciences. The survey's objective was to define what sharks occurred in the area, their sizes, life stages, relative abundances and seasonal occurrences. Relative abundance indices from this survey have been previously generated for smooth dogfish covering the time period from 1972 to 2005 (Schwartz et al. 2007). In this document, the time series is updated with data through 2013, including data corrections detailing missing water hauls and missing or incorrect information pertaining to individual animal records.

Methods

Sampling gear

An unanchored longline, approximately 4.8 km long of braided nylon (about 7.6 mm diameter) was suspended by orange 1.3 m diameter polyfoam plastic floats spaced every 10 hooks, spacing between hooks was 4.5 m. Gangions were 1.8 m long of No. 2 (95 kg) porch swing chain terminating in a No. 9 Mustad tuna hook. This gear was not altered throughout the 40 + years of sampling. The number of hooks varied more during early sample years and less during later years, rarely less than 100 hooks per set. Bait was fresh fish trawled near Beaufort Inlet, North Carolina, usually consisting of spot *Leiostomus xanthus* and Atlantic croaker *Micropogonias undulatus*, occasionally pigfish *Orthopristis chrysptera* and pinfish *Lagodon rhombiodes*.

Survey design

A bi-weekly shark survey occurred between April and November at two fixed stations 1-3.4 km south of Shackleford Banks in Onslow Bay, NC. The daily sampling protocol generally included an early morning set at the east-west (E-W) station, followed by a later set in the day at the north-south (N-S) station. The shallow (13 m) E-W set was over sandy-silt and the deeper (22 m) N-S set was primarily over sandy areas. Weather occasionally prevented occupying both stations on a single day. Soak time was one hour, to avoid longer intervals that would often produce dead or dying sharks. Surface water temperatures were recorded at the beginning of the set. Fork length and sex were recorded for each shark species caught. Any specimen that was partially eaten, damaged or lost during line retrieval was counted but not measured.

Data Analysis

Catch per unit effort (CPUE) in number of sharks per hook were used to examine the relative abundance of smooth dogfish caught during the UNC longline survey conducted between 1972 and 2013 in Onslow Bay, NC. 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 the CPUE for these analyses were: year (1972 – 2013), month (April – November), station (E-W, N-S), and temperature (<20 deg C, 20-24 deg C, 25-29 deg C, and 30+ deg C). The proportion of sets with positive CPUE values was modeled assuming a binomial distribution with a logit link function and the positive CPUE 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 providing 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 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 766 smooth dogfish were caught during 993 longline sets from 1972 to 2013. Smooth dogfish ranged in length from 25 to 120 cm FL, and there was an overall decreasing trend in size over time (Figure 1). This decreasing trend can be partially attributed to the lack of smaller fish in the catches during the early years, potentially due to the decreased effort during that time. The proportion of sets with positive catch (at least one smooth dogfish was caught) was 12%. There were 10 years without any smooth dogfish catches (1973, 1975, 1991, 1995, 1999-2002, and 2012-2013). The majority of catches occurred during April and early May (82%), which were not consistently sampled across years due to weather and logistical constraints. The maximum number of sets that can be conducted from April 1 to May 15 based on survey design is 8 sets. The number of sets conducted between April 1 and May 15 averaged of 3 sets across all years. The stepwise construction of each model and the resulting statistics are detailed in Table 1. Model diagnostic plots reveal that the model fit is acceptable (Figures 2a and 2b). 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 Figures 3 and 4. The standardized relative abundance for smooth dogfish shows an overall slight decreasing trend throughout the time series with peaks in abundance in 2005 and 2010 (Figures 3 and 4).

References

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Table 1. Results of the stepwise procedure for development of the UNC longline survey catch rate model for smooth dogfish. DF is the degrees of freedom. %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/DF	%DIFF	DELTA%
NULL	657	609.5450	0.9278		
MONTH	650	321.3011	0.4943	46.7234	46.7234
TEMP	654	478.6191	0.7318	21.1252	
YEAR	616	514.8465	0.8358	9.9159	
STATION	655	607.3090	0.9272	0.0647	
MONTH +					
YEAR	609	210.9453	0.3464	62.6644	15.9409
TEMP	647	319.9876	0.4946	46.6911	-0.0323

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
MONTH + YEAR	792.3	795.1	790.3

Type 3 Test of Fixed Effects

	MONTH	YEAR
Significance (Pr>Chi) of Type 3 test of fixed effects for each factor	<.0001	0.7371
DF	5	31
CHI SQUARE	50.92	25.67

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%
NULL	114	143.3843	1.2578		
MONTH	109	105.4381	0.9673	23.0959	23.0959
TEMP	112	131.2922	1.1723	6.7976	
YEAR	83	105.7184	1.2737	-1.2641	
STATION	113	143.3843	1.2689	-0.8825	
MONTH +					
YEAR	78	76.0777	0.9754	22.4519	-0.6440
TEMP	107	105.2531	0.9837	21.7920	-1.3039

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
MONTH + YEAR	186.0	187.9	184.0

Type 3 Test of Fixed Effects

	MONTH	YEAR
Significance (Pr>Chi) of Type 3 test of fixed effects for each factor	<.0001	0.9963
DF	5	31
CHI SQUARE	36.68	14.00

Table 2. UNC longline survey smooth dogfish analysis number of model observations per year (n obs), number of positive model observations per year (obs pos), proportion of positive model observations 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
1972	3	1	0.3333	0.0167	0.0581	0.0105	0.3207	1.0372
1973	6	0	0	0	.	.	.	.
1974	12	3	0.2308	0.0378	0.0209	0.0034	0.1292	1.1351
1975	15	0	0	0	.	.	.	.
1976	20	3	0.1429	0.0107	0.0063	0.0009	0.0422	1.2152
1977	15	4	0.2667	0.0412	0.0696	0.0177	0.2731	0.7719
1978	15	6	0.3750	0.0310	0.0492	0.0164	0.1480	0.5950
1979	19	5	0.2500	0.0329	0.0387	0.0098	0.1530	0.7779
1980	20	8	0.4000	0.0387	0.0551	0.0212	0.1436	0.5075
1981	18	6	0.3158	0.0317	0.0432	0.0130	0.1432	0.6571
1982	22	3	0.1364	0.0085	0.0180	0.0037	0.0880	0.9372
1983	18	5	0.2632	0.0186	0.0554	0.0164	0.1869	0.6687
1984	19	5	0.2381	0.0241	0.0444	0.0135	0.1459	0.6513
1985	14	2	0.1429	0.0032	0.0144	0.0024	0.0854	1.0968
1986	11	3	0.2500	0.0141	0.0168	0.0034	0.0838	0.9528
1987	14	3	0.2143	0.0189	0.0381	0.0084	0.1727	0.8779
1988	14	2	0.1333	0.0114	0.0157	0.0022	0.1139	1.2941
1989	17	4	0.2353	0.0113	0.0095	0.0020	0.0460	0.9299
1990	13	1	0.0769	0.0154	0.0051	0.0005	0.0563	1.7955
1991	11	0	0	0	.	.	.	.
1992	9	1	0.1111	0.0044	0.0226	0.0029	0.1736	1.3507
1993	7	1	0.1429	0.0038	0.0191	0.0026	0.1393	1.2961
1994	12	2	0.1667	0.0022	0.0050	0.0005	0.0467	1.5728
1995	13	0	0	0				
1996	16	2	0.1250	0.0045	0.0261	0.0050	0.1361	0.9876
1997	13	1	0.0769	0.0039	0.0022	0.0002	0.0263	1.9369
1998	15	2	0.1333	0.0133	0.0142	0.0020	0.1003	1.2661
1999	11	0	0	0	.	.	.	.
2000	15	0	0	0	.	.	.	.
2001	10	0	0	0	.	.	.	.
2002	14	0	0	0	.	.	.	.
2003	15	1	0.0667	0.0020	0.0007	0.0001	0.0081	1.7847
2004	11	3	0.2500	0.0135	0.0254	0.0040	0.1625	1.1686
2005	9	4	0.4444	0.0305	0.1105	0.0395	0.3094	0.5509
2006	14	2	0.1429	0.0157	0.0433	0.0072	0.2619	1.1159
2007	11	1	0.0909	0.0027	0.0010	0.0001	0.0110	1.8568
2008	15	1	0.0667	0.0020	0.0009	0.0001	0.0100	1.8239
2009	10	1	0.1000	0.0021	0.0149	0.0020	0.1087	1.2979
2010	9	1	0.1111	0.0111	0.0696	0.0095	0.5093	1.3006
2011	15	1	0.0667	0.0033	0.0012	0.0001	0.0128	1.7668
2012	11	0	0	0	.	.	.	.
2013	8	0	0	0	.	.	.	.

Figure 1. Fork lengths (cm) of smooth dogfish caught during the UNC longline survey from 1973-2013.

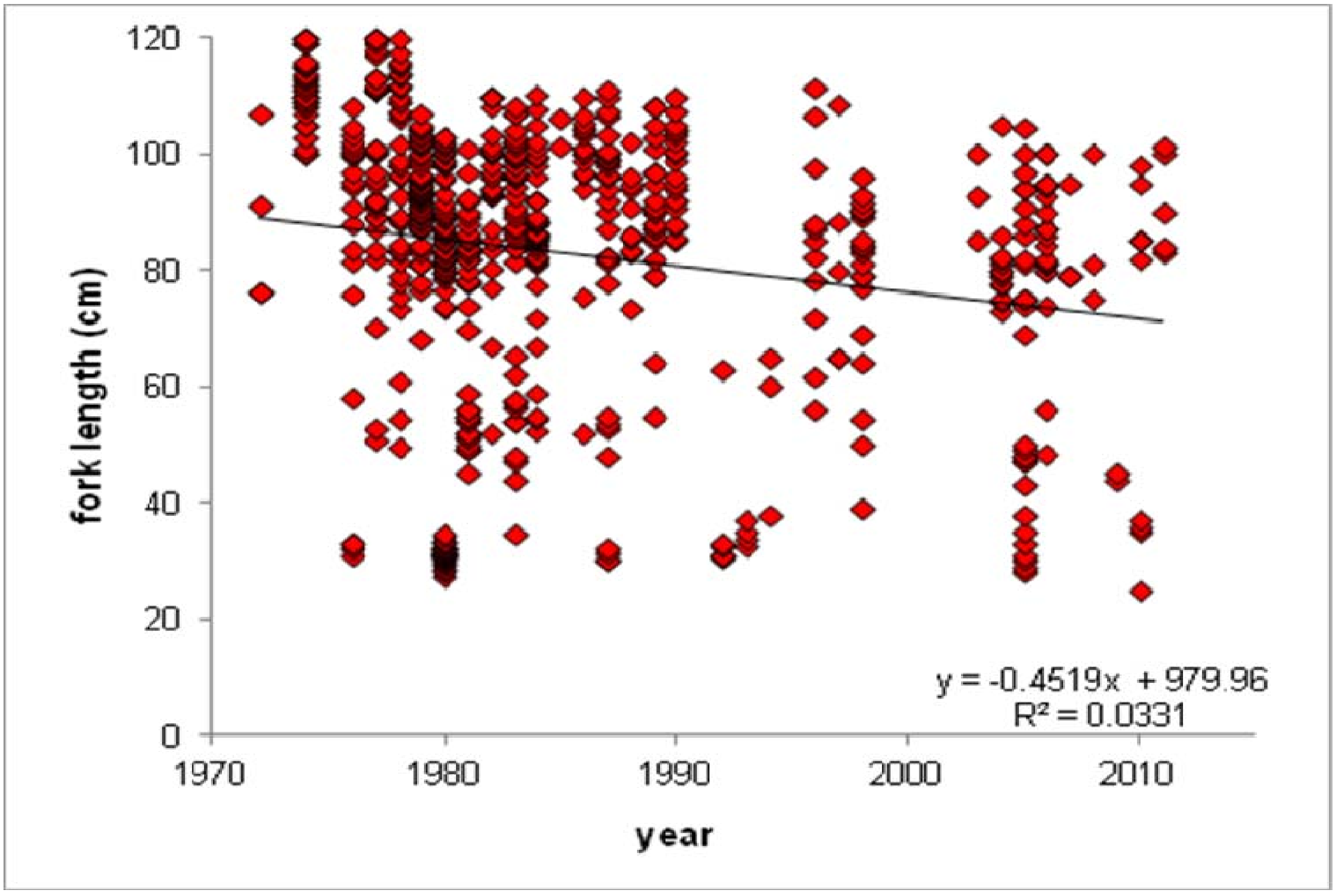
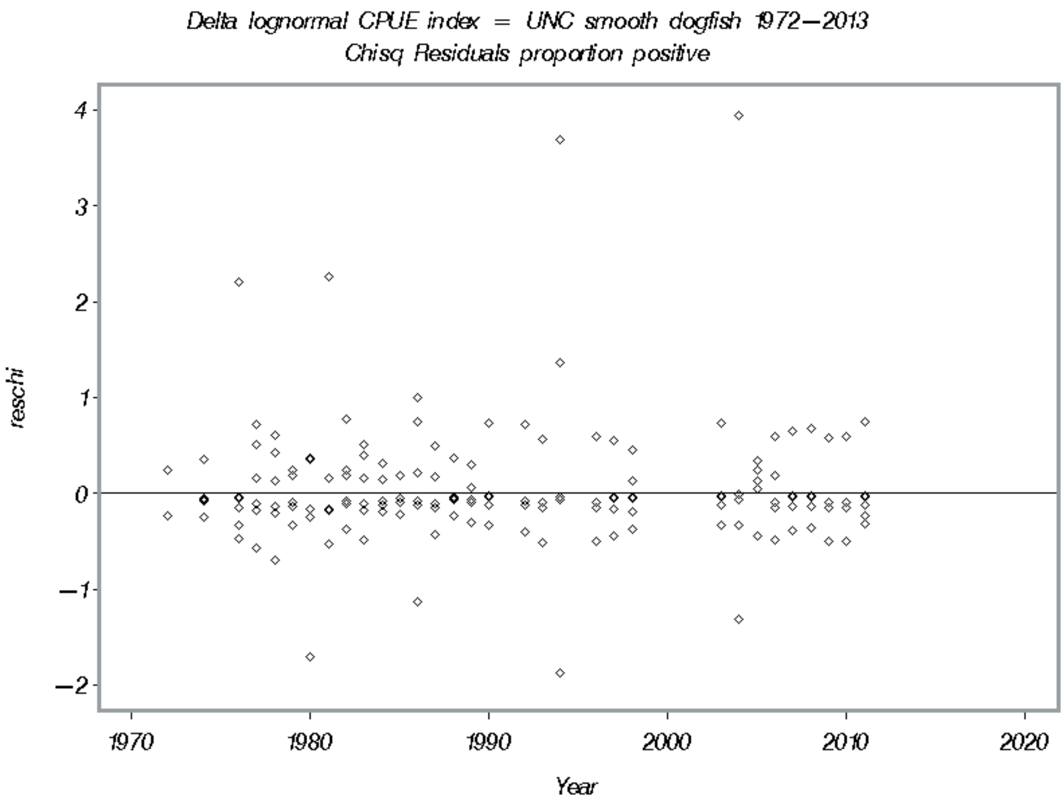


Figure 2a. UNC smooth dogfish model diagnostic plots for the binomial component.



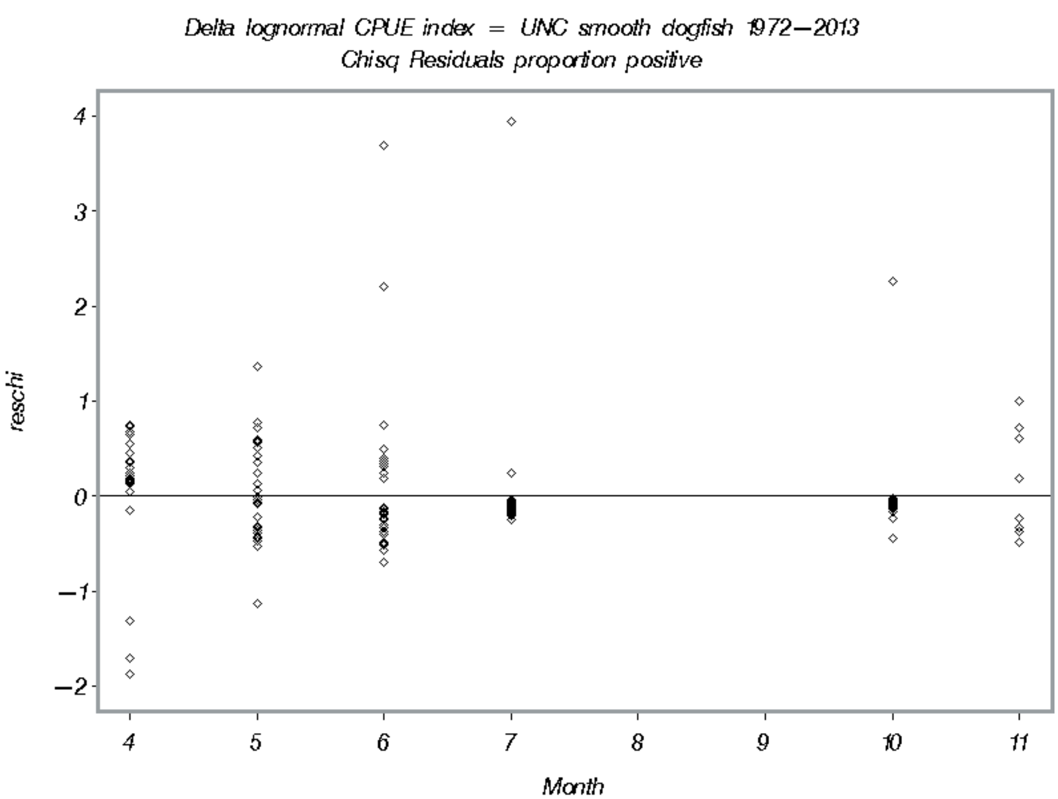


Figure 2a continued. UNC smooth dogfish model diagnostic plots for the binomial component.

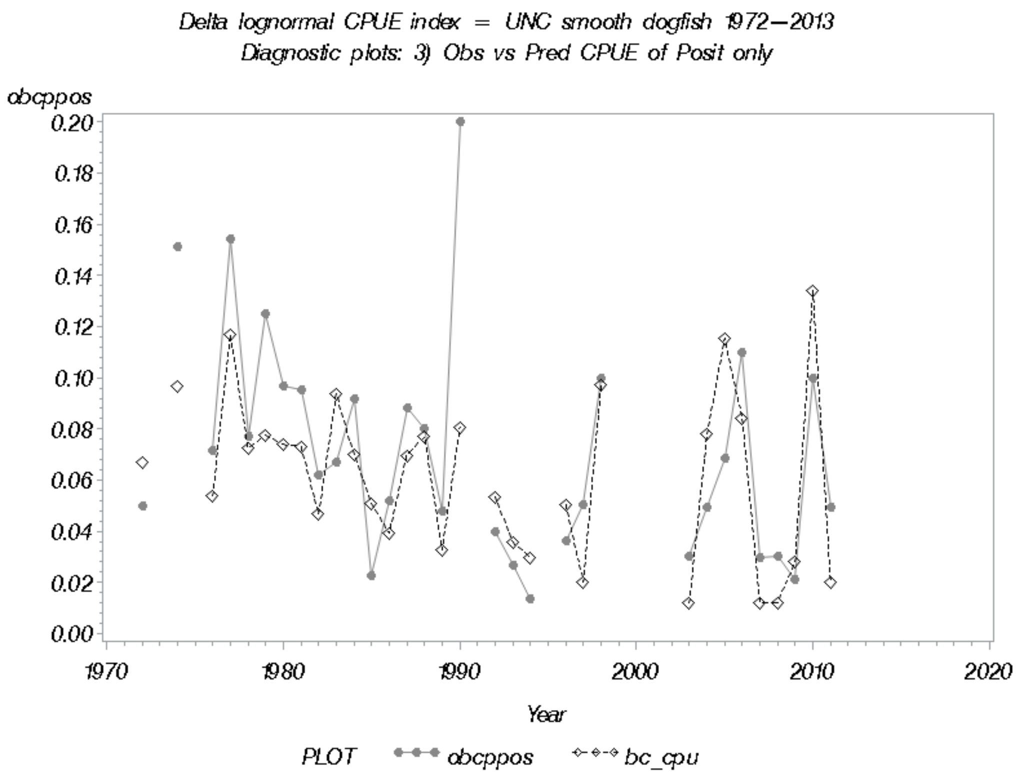


Figure 2b. UNC smooth dogfish model diagnostic plots for lognormal component.

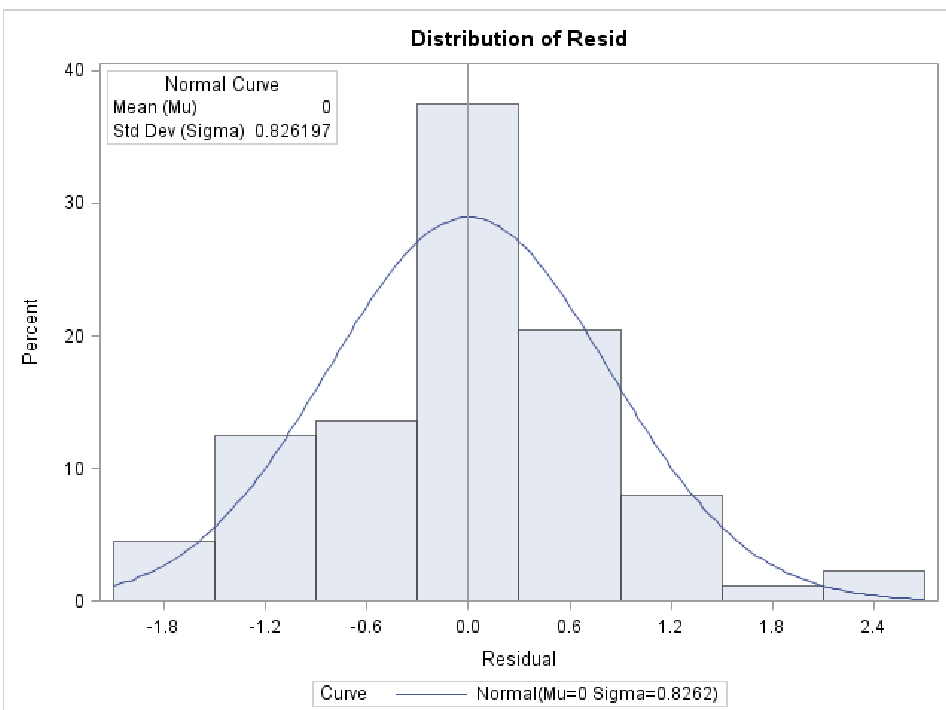
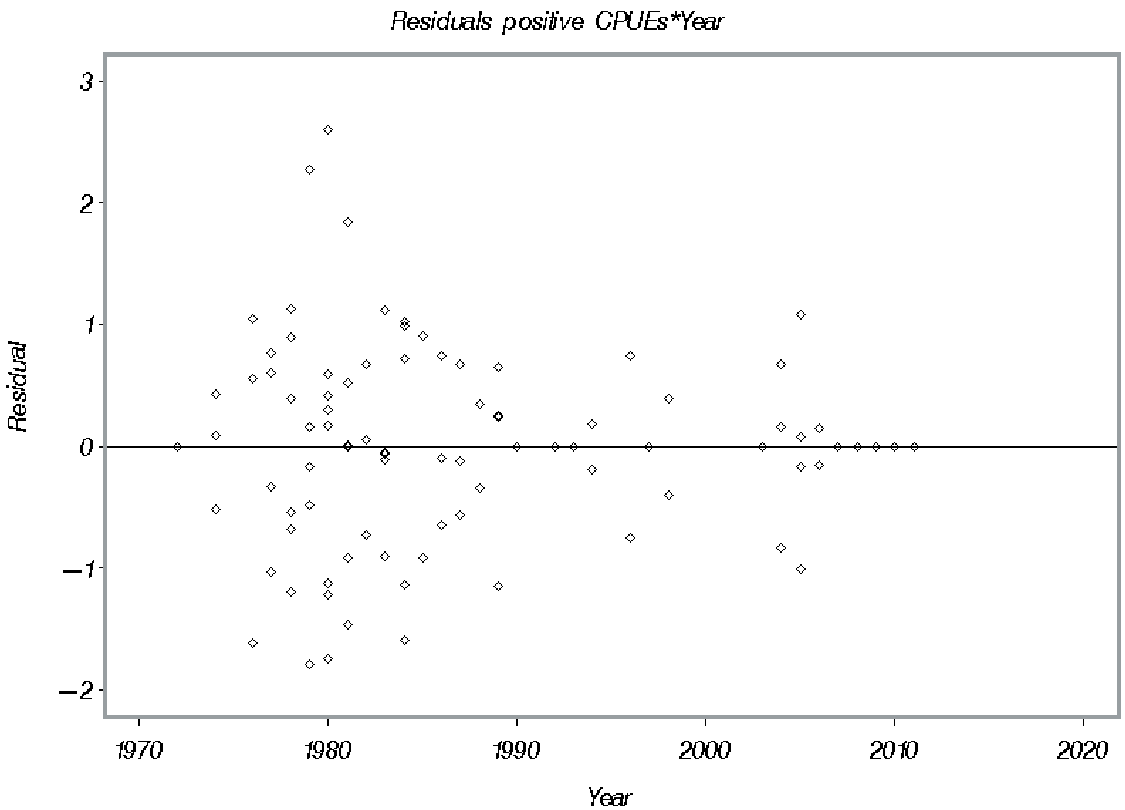


Figure 2b continued. UNC smooth dogfish model diagnostic plots for lognormal component.



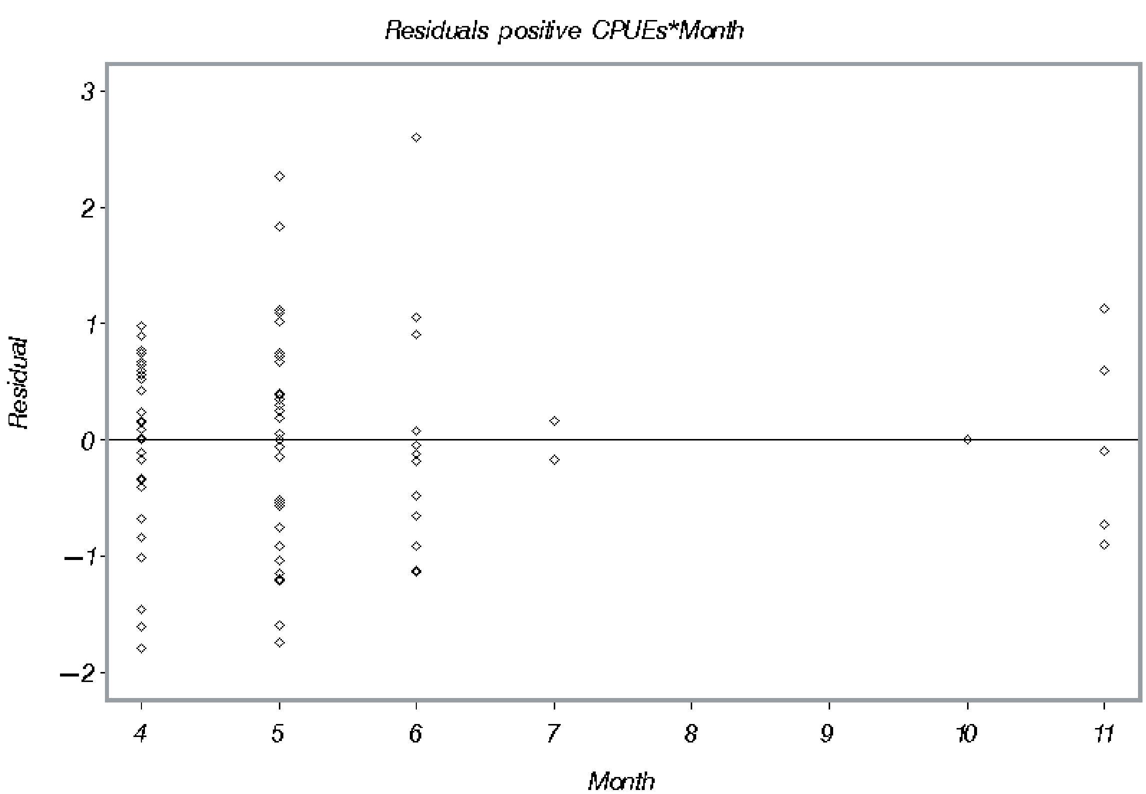


Figure 2b continued. UNC smooth dogfish model diagnostic plots for lognormal component.

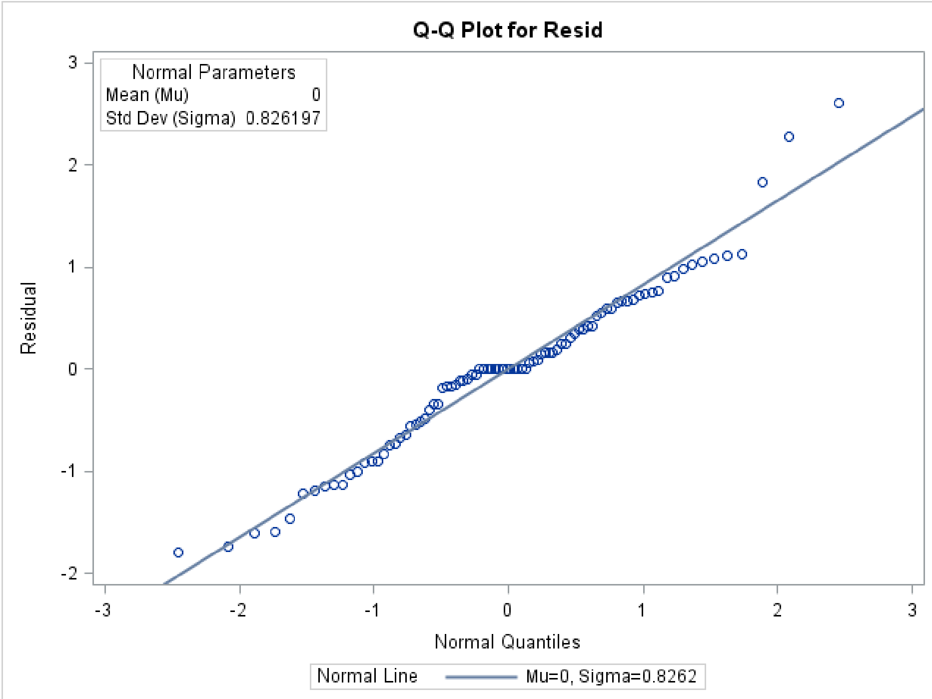


Figure 3. UNC smooth dogfish nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCI0, UCI0).

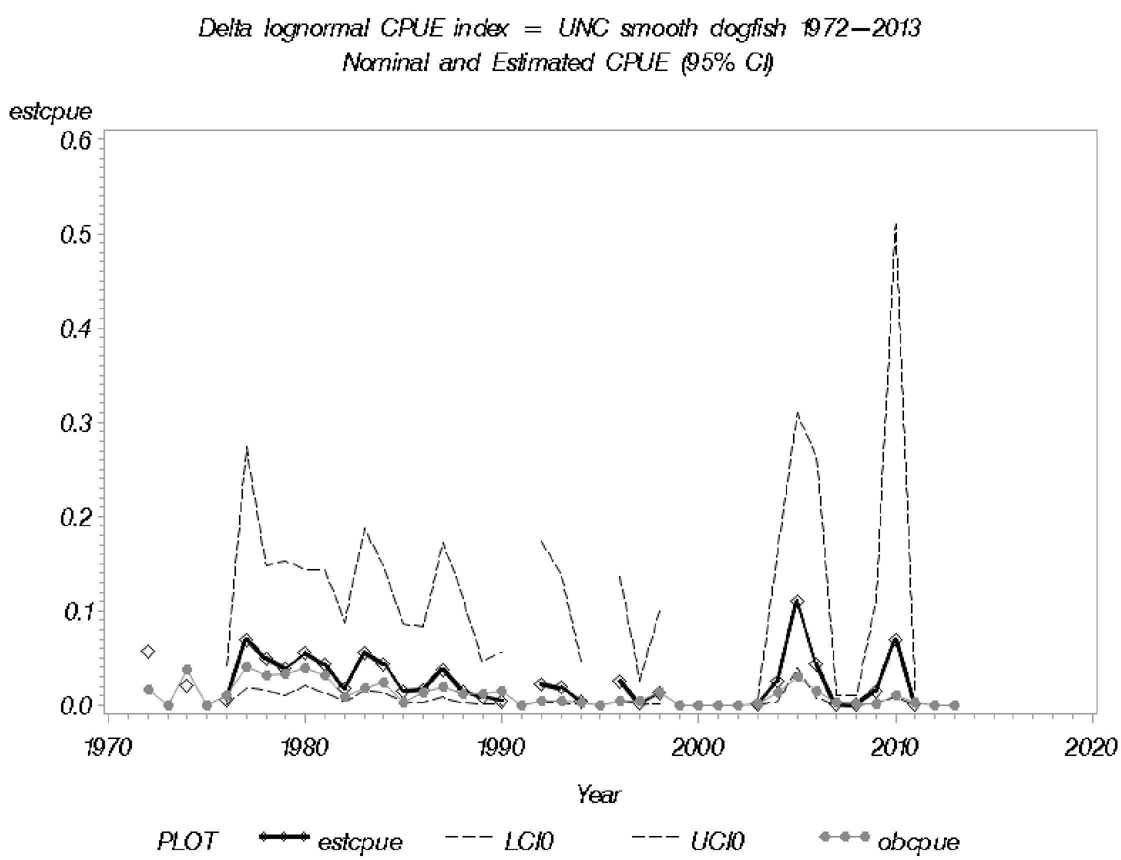


Figure 4. Plot of the standardized index of abundance over time with a linear trend line