Standardized indices of abundance for Smooth Dogfish, *Mustelus canis*, from the Long Island Sound Trawl Survey conducted by the Connecticut Department of Energy and Environmental Protection

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SEDAR39-DW-12

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SEDAR 39 DATA WORKSHOP DOCUMENT

Standardized indices of abundance for Smooth Dogfish, *Mustelus canis*, from the Long Island Sound Trawl Survey conducted by the Connecticut Department of Energy and Environmental Protection.

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Summary

This document details the smooth dogfish catch from the Long Island Sound Trawl Survey conducted during the spring and fall from 1984 to 2013. There was no fall survey in 2010 when the research vessel was in service. Catch per unit effort (CPUE) in number of sharks per 30 minute tow was 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. The nominal and standardized relative abundance for smooth dogfish show an overall increasing trend throughout the majority of the time series with a large peak in 2002 and a notable drop in 2010. The peak occurs in a year when a high proportion of sets had smooth dogfish catch, and many of them in large numbers. The 2010 drop in abundance can be partially attributed to a substantial reduction in effort that year. Both a large peak in 2002 and a less substantial drop in 2010 relative abundance were seen in New Jersey coastal waters.

Introduction

The Long Island Sound (LIS) Trawl Survey was initiated in 1984 to provide fishery independent monitoring of important recreational species in Long Island Sound. A stratified-random design based on bottom type and depth interval was chosen and forty sites were sampled monthly from April through November to establish seasonal patterns of abundance and distribution. In 1991, the sampling schedule was changed to a spring/fall format, although sampling is still conducted on a monthly basis (April - June, September and October). The goal of the LIS Trawl Survey is to collect, manage, synthesize and interpret fishery independent data on the living resources of LIS for fishery management and information needs of Connecticut biologists, fishery managers, lawmakers and the public. In this document, the LIS Trawl Survey seasonal time series is modeled to create a standardized index of abundance for smooth dogfish.

Methods

Sampling gear and survey design

The LIS Trawl Survey uses a 14 m otter trawl, with a 51 mm codend, which is towed from the 15.2 m aluminum *R/V John Dempsey*. The survey is conducted from longitude 72^o 03' (New London, Connecticut) to longitude 73^o 39' (Greenwich, Connecticut). The sampling area includes Connecticut and New York waters from 5 to 46 m in depth and is conducted over mud, sand and transitional (mud/sand) sediment types. Sampling is divided into spring (April-June) and fall (Sept-Oct) periods, with 40 sites sampled monthly for a total of 200 sites annually. Sampling is conducted during daylight hours only.

A stratified-random sampling design is used. The sampling area is divided into 1.85 x 3.7 km (1 x 2 nautical miles) sites (Figure 2.1), with each site assigned to one of 12 strata defined by depth interval (0 - 9.0 m, 9.1 - 18.2 m, 18.3 - 27.3 m or, 27.4+ m) and bottom type (mud, sand, or transitional as defined by Reid et al. 1979). For each monthly sampling cruise, sites are selected randomly from within each stratum. The number of sites sampled in each stratum was determined by dividing the total stratum area by 68 km^2 (20 square nautical miles), with a minimum of two sites sampled per stratum (Table 2.2). Discrete stratum areas smaller than a sample site are not sampled.

Prior to each tow since 1992, temperature (^{o}C) and salinity (ppt) are measured at 1 m below the surface and 0.5 m above the bottom using a YSI model 30 S-C-T meter and water is collected at depth with a five-liter Niskin bottle, and temperature and salinity are measured within the bottle immediately upon retrieval. The survey's otter trawl is towed for 30 minutes at approximately 3.5 knots, depending on the tide. At completion of the tow, the catch is placed onto a sorting table and sorted by species. Finfish, lobsters and squid are counted and weighed in aggregate (to the nearest 0.1 kg) by species. The length (mm total length) and sex of some smooth dogfish were recorded from 2002 to present. Length data without sex was recorded for some smooth dogfish in 1989, 1990, 2000, and 2001. Length and sex data were recorded for all smooth dogfish since 2008.

No survey was conducted in June 2010 or either month of the fall 2010 survey because the research vessel was out of service.

Data Analysis

Catch per unit effort (CPUE) in number of sharks per 30 minute tow were used to examine the relative abundance of smooth dogfish caught during the Long Island Sound Trawl Survey conducted between 1984 and 2013. The CPUE was standardized using the Lo et al. (2002) method which models the proportion of positive tows separately from the positive catch. Factors considered as potential influences on the CPUE for these analyses were: year (1984– 2013), month (April, May, June, September, October), depth interval (0 - 9.0 m, 9.1 - 18.2 m, 18.3 - 27.3 m or, 27.4+ m), and bottom type (mud, sand, or transitional). Temperature and salinity were not considered in developing the model to preserve the entire length of the time series. The proportion of tows with positive CPUE values was modeled assuming a binomial distribution with a logit link function and the positive CPUE tows 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.

Available smooth dogfish lengths were converted from total length to fork length using the following formulas (provided by the SEDAR 39 Life History Working Group Chair, William B. Driggers):

$$\text{Sexes combined: } TLcm = 3.43329 + 1.09539*FLcm$$

$$\text{Female: } TLcm = 3.64854 + 1.0939*FLcm$$

$$\text{Male: } TLcm = 4.70063 + 1.07726*FLcm$$

Results

A total of 12643 smooth dogfish were caught during 5553 tows from 1984 to 2013. Smooth dogfish ranged in length from 17 to 126 cm FL (Figure 1). There is a slight reduction in size over time, but this trend is not evident when looking at the years when smooth dogfish lengths were recorded more consistently (2002-2013). The proportion of tows with positive catch (at least one smooth dogfish was caught) was 38%. 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 nominal and standardized relative abundance for smooth dogfish show an overall increasing trend throughout the majority of the time series with a large peak in 2002 and a notable drop in 2010 (Figures 3 and 4). The peak occurs in a year when a high proportion of sets had smooth dogfish catch, and many of them in large numbers. The drop in abundance can be partially attributed to a substantial reduction in effort that year. Both a large peak in 2002 and drop (although less substantial) in 2010 relative abundance were seen in New Jersey coastal waters (McCandless et al. 2014).

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Table 1. Results of the stepwise procedure for development of the LIS Trawl 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	1657	2265.9061	1.3675		
MONTH	1653	1543.8587	0.9340	31.7002	31.7002
DEPTH	1654	2142.3411	1.2952	5.2870	
YEAR	1628	2194.6964	1.3481	1.4186	
BOTTOM	1655	2244.4913	1.3562	0.8263	
MONTH +					
DEPTH	1650	1347.8341	0.8169	40.2633	8.5631
YEAR	1624	1455.1151	0.8960	34.4790	2.7788
MONTH + DEPTH +					
YEAR	1621	1243.8891	0.7674	43.8830	3.6197

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
MONTH + DEPTH + YEAR	9074.4	9079.8	9072.4

Type 3 Test of Fixed Effects

Significance (Pr>Chi) of Type 3	MONTH	DEPTH	YEAR
test of fixed effects for each factor	<.0001	<.0001	<.0001
DF	4	3	29
CHI SQUARE	271.68	204.73	103.25

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%
NULL	944	1426.4305	1.5110		
MONTH	940	1266.8312	1.3477	10.8074	10.8074
DEPTH	941	1310.8603	1.3931	7.8028	
YEAR	915	1285.4751	1.4049	7.0218	
BOTTOM	942	1390.6987	1.4763	2.2965	
MONTH +					
DEPTH	937	1139.1744	1.2158	19.5367	8.7293
YEAR	911	1131.596	1.2421	17.7962	6.9887
BOTTOM	938	1226.0726	1.3071	13.4944	2.6870
MONTH + DEPTH +					
YEAR	908	987.9553	1.0881	27.9881	8.4514
BOTTOM	935	1086.4643	1.1620	23.0973	3.5606
MONTH + DEPTH + YEAR +					
BOTTIOM	906	935.4743	1.0325	31.6678	3.6797

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
MONTH + DEPTH + YEAR + BOTTOM	2744.8	2749.6	2742.8

Type 3 Test of Fixed Effects

Significance (Pr>Chi) of Type 3	MONTH	DEPTH	YEAR	BOTTOM
test of fixed effects for each factor	<.0001	<.0001	<.0001	<.0001
DF	4	3	29	2
CHI SQUARE	170.38	151.12	146.23	50.83

Table 2. LIS Trawl Survey smooth dogfish analysis number of sets (n tows), number of sharks (catch), 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 catch per 30 minute tow (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 tows	catch	n obs	obs pos	obs ppos	obs cpue	est cpue	LCL	UCL	CV
1984	102	534	42	25	0.5952	12.7143	7.5274	3.9324	14.4090	0.3334
1985	126	405	39	30	0.7692	10.3846	12.5402	7.8275	20.0904	0.2390
1986	196	430	60	38	0.6333	7.1667	7.7254	5.0354	11.8522	0.2165
1987	200	257	60	24	0.4000	4.2833	3.0889	1.5671	6.0886	0.3493
1988	200	385	60	33	0.5500	6.4167	5.1271	3.0766	8.5442	0.2596
1989	200	202	60	33	0.5500	3.3667	4.0179	2.4124	6.6917	0.2593
1990	200	209	60	30	0.5000	3.4833	2.9496	1.6791	5.1815	0.2874
1991	200	193	60	31	0.5167	3.2167	3.6991	2.1426	6.3865	0.2782
1992	160	304	48	26	0.5417	6.3333	3.9966	2.1088	7.5744	0.3280
1993	240	420	60	28	0.4667	7.0000	4.3122	2.3634	7.8678	0.3076
1994	240	361	60	36	0.6000	6.0167	5.6161	3.5465	8.8935	0.2329
1995	200	168	60	31	0.5167	2.8000	3.3101	1.9184	5.7114	0.2779
1996	200	275	57	35	0.6140	4.8246	4.8589	3.0186	7.8211	0.2414
1997	200	167	60	24	0.4000	2.7833	2.1227	1.0766	4.1854	0.3495
1998	200	310	60	31	0.5167	5.1667	4.0932	2.3718	7.0640	0.2780
1999	200	305	60	39	0.6500	5.0833	7.3655	4.8728	11.1331	0.2088
2000	200	467	60	35	0.5833	7.7817	9.4375	5.8632	15.1909	0.2414
2001	200	598	60	33	0.5500	9.9583	9.4136	5.6517	15.6796	0.2593
2002	200	1019	60	43	0.7167	16.9850	21.9567	15.3418	31.4237	0.1807
2003	160	552	48	23	0.4792	11.5042	10.7696	5.7167	20.2886	0.3248
2004	199	503	60	35	0.5833	8.3867	7.2802	4.5227	11.7189	0.2414
2005	200	467	60	28	0.4667	7.7767	5.8828	3.2257	10.7286	0.3074
2006	120	332	40	28	0.7000	8.3000	6.2153	3.6051	10.7153	0.2775
2007	200	580	59	35	0.5932	9.8339	9.5904	5.9549	15.4454	0.2417
2008	160	328	48	27	0.5625	6.8292	9.5611	5.7243	15.9696	0.2608
2009	200	588	60	37	0.6167	9.8000	11.3467	7.2818	17.6807	0.2245
2010	78	10	24	5	0.2083	0.4208	3.4609	1.1768	10.1785	0.5811
2011	172	613	53	36	0.6792	11.5679	11.6632	7.3625	18.4761	0.2331
2012	200	610	60	45	0.7500	10.1733	14.0292	9.9785	19.7241	0.1716
2013	200	1051	60	41	0.6833	17.5167	14.9516	10.1787	21.9626	0.1941

Figure 1. Fork lengths (cm) of smooth dogfish caught during the LIS Trawl Survey from 1989-1990 and 2000-2013.

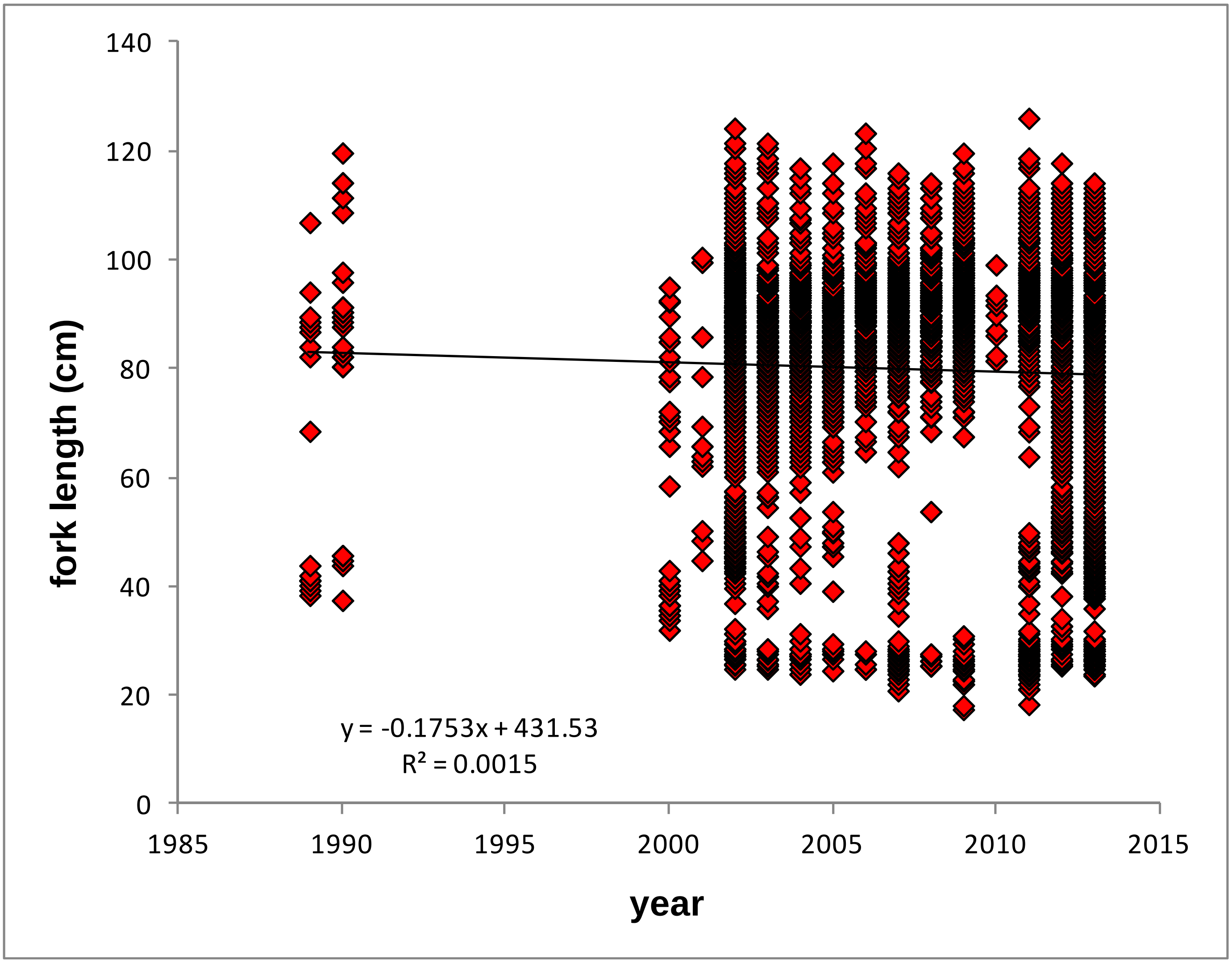
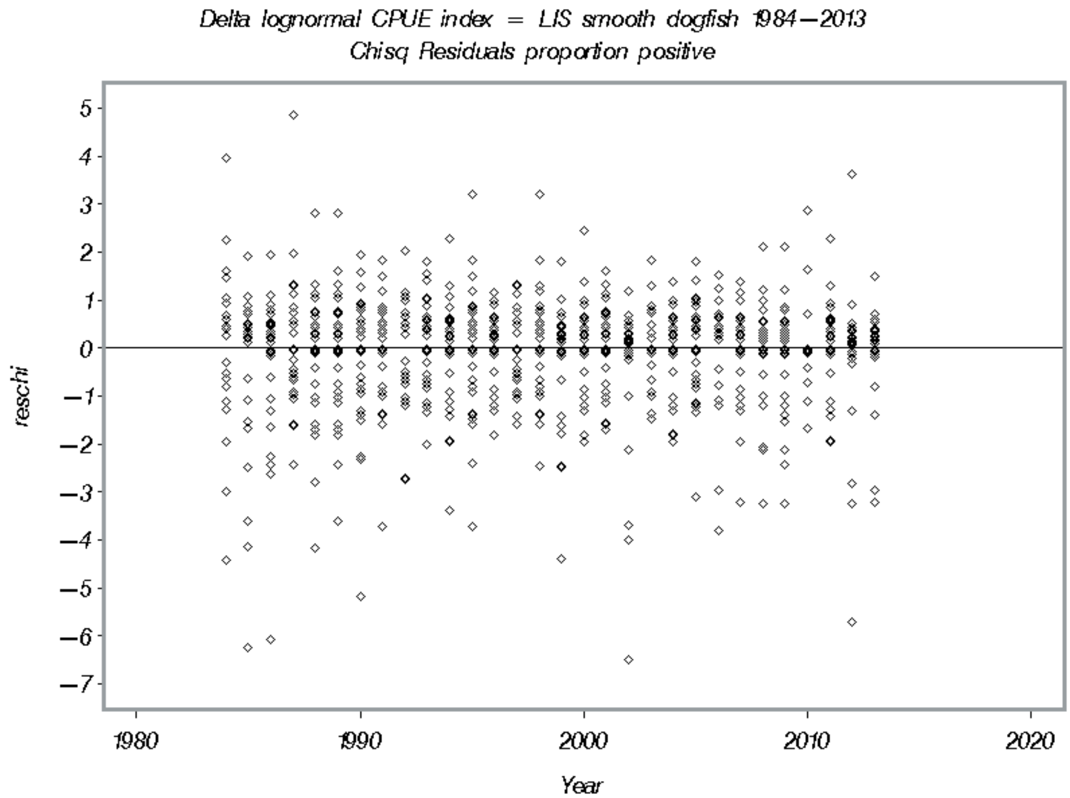


Figure 2a. LIS smooth dogfish model diagnostic plots for the binomial component.



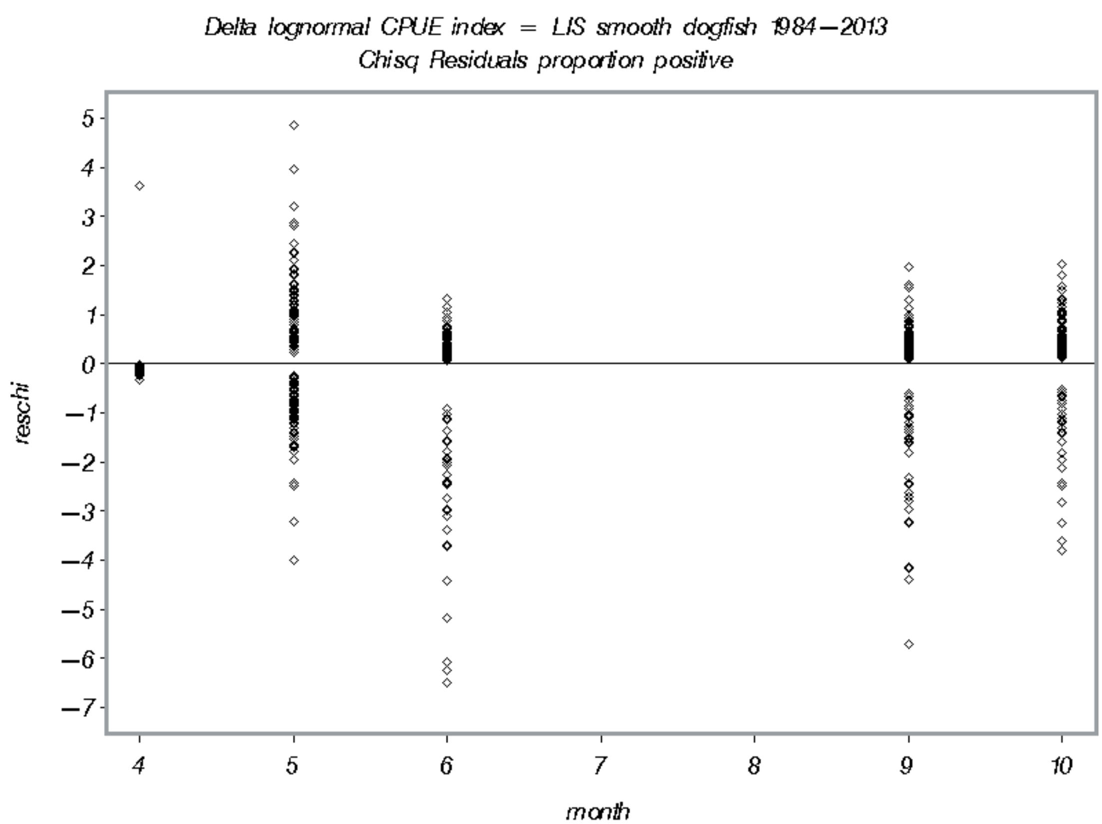
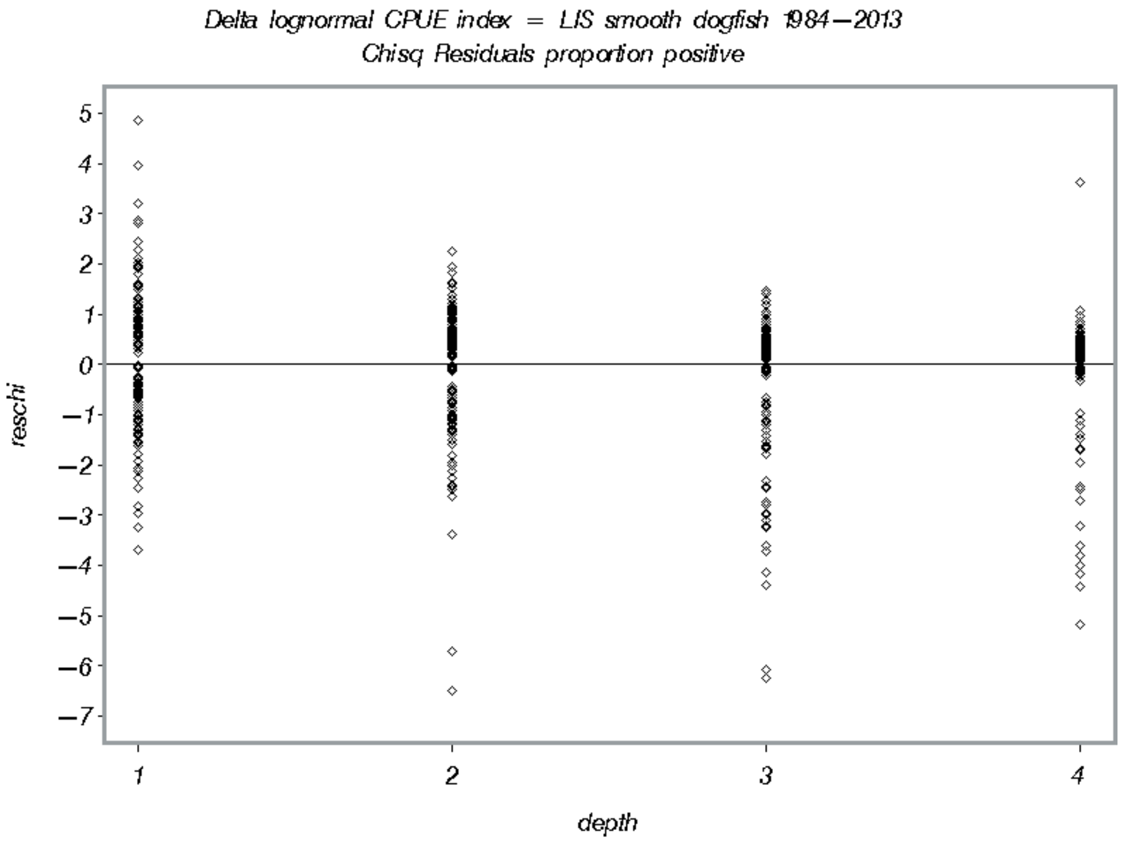


Figure 2a continued. LIS smooth dogfish model diagnostic plots for the binomial component.



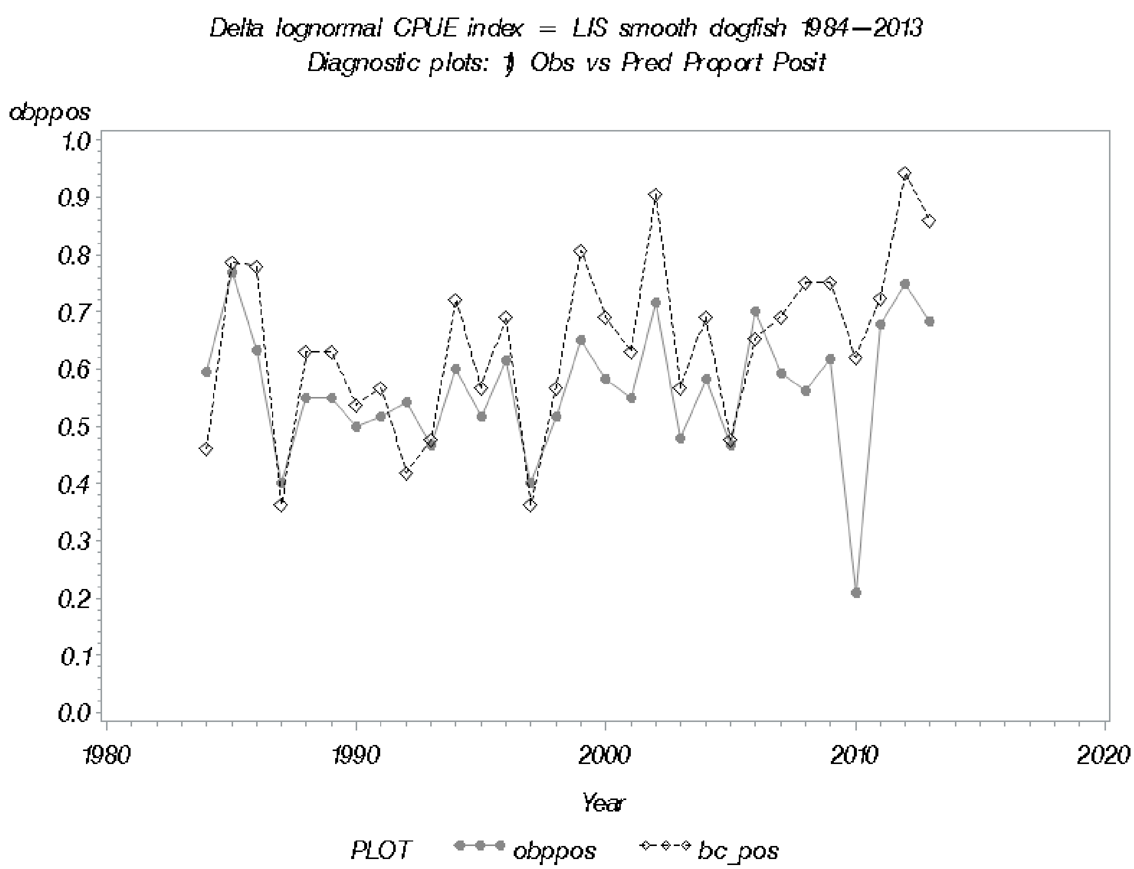
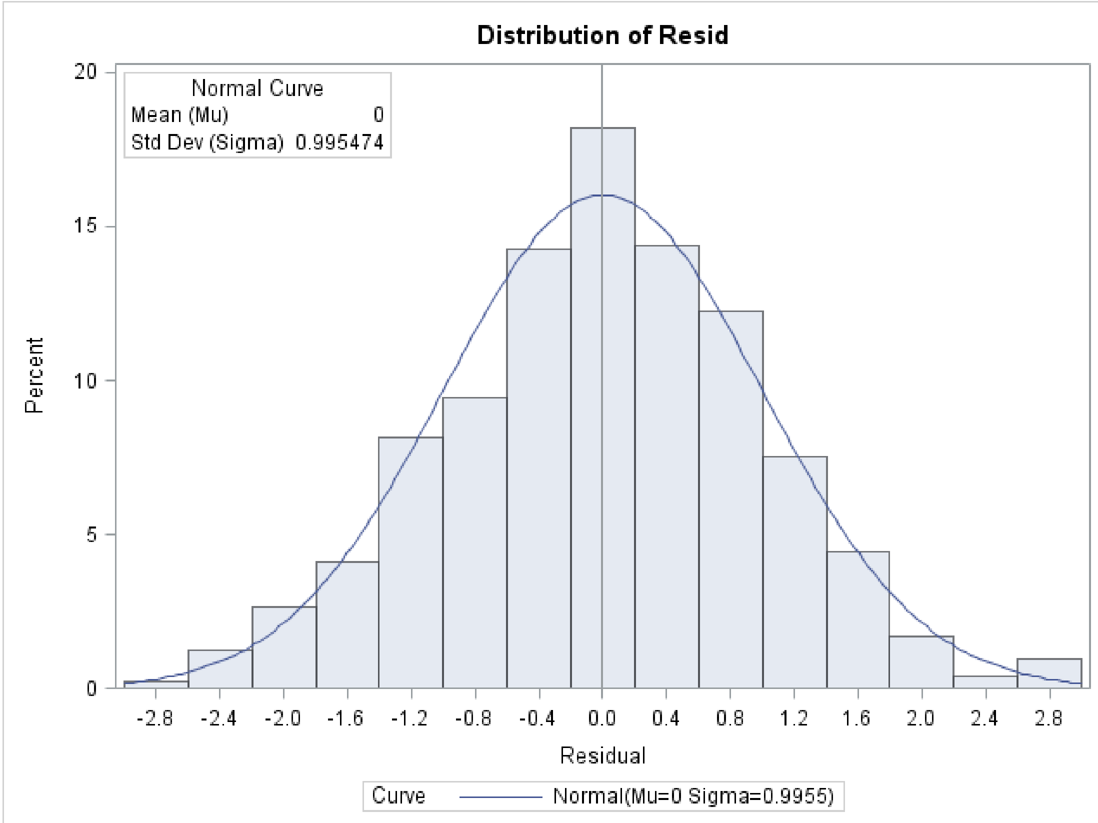


Figure 2b. LIS smooth dogfish model diagnostic plots for lognormal component.



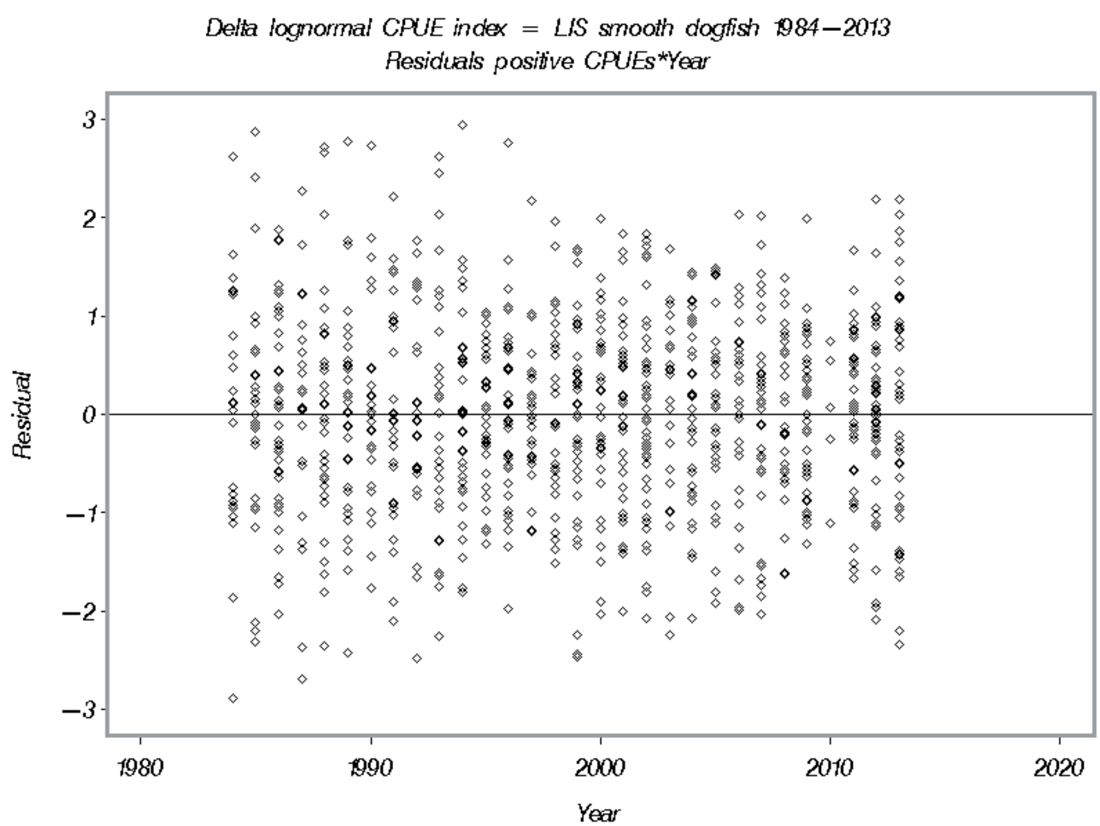
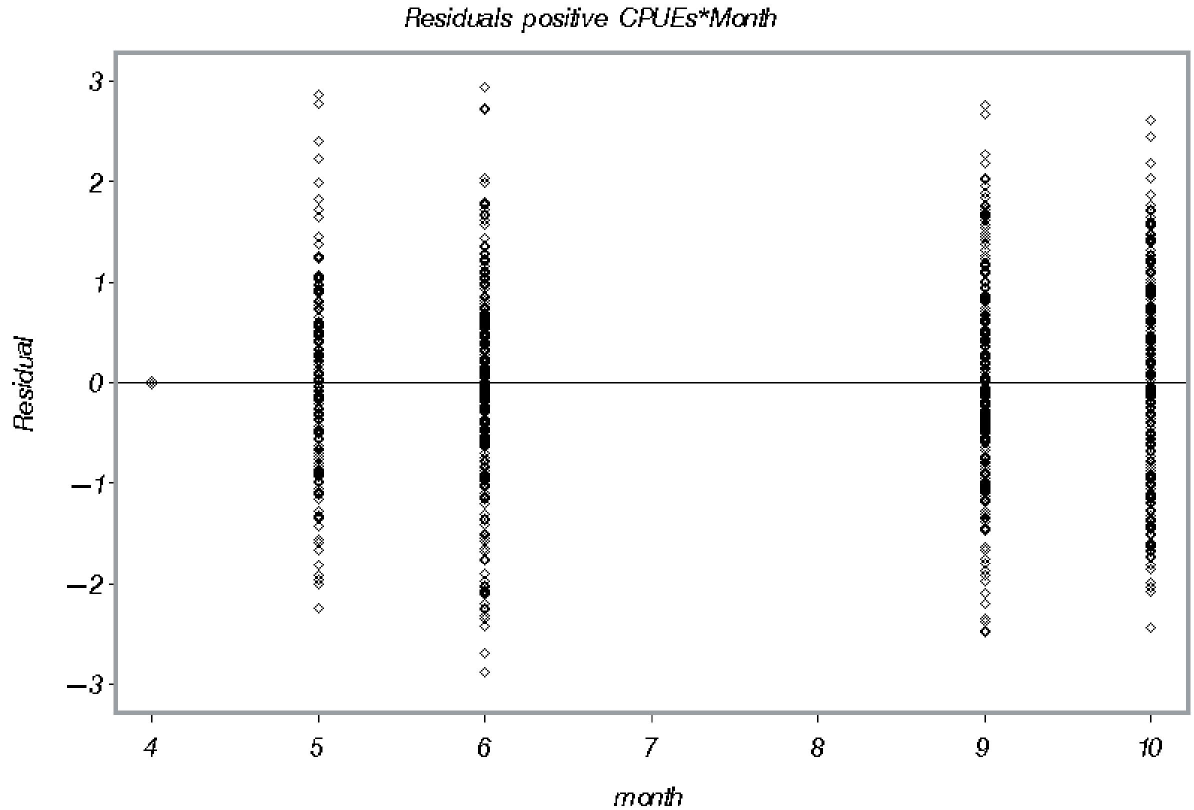


Figure 2b continued. LIS smooth dogfish model diagnostic plots for lognormal component.



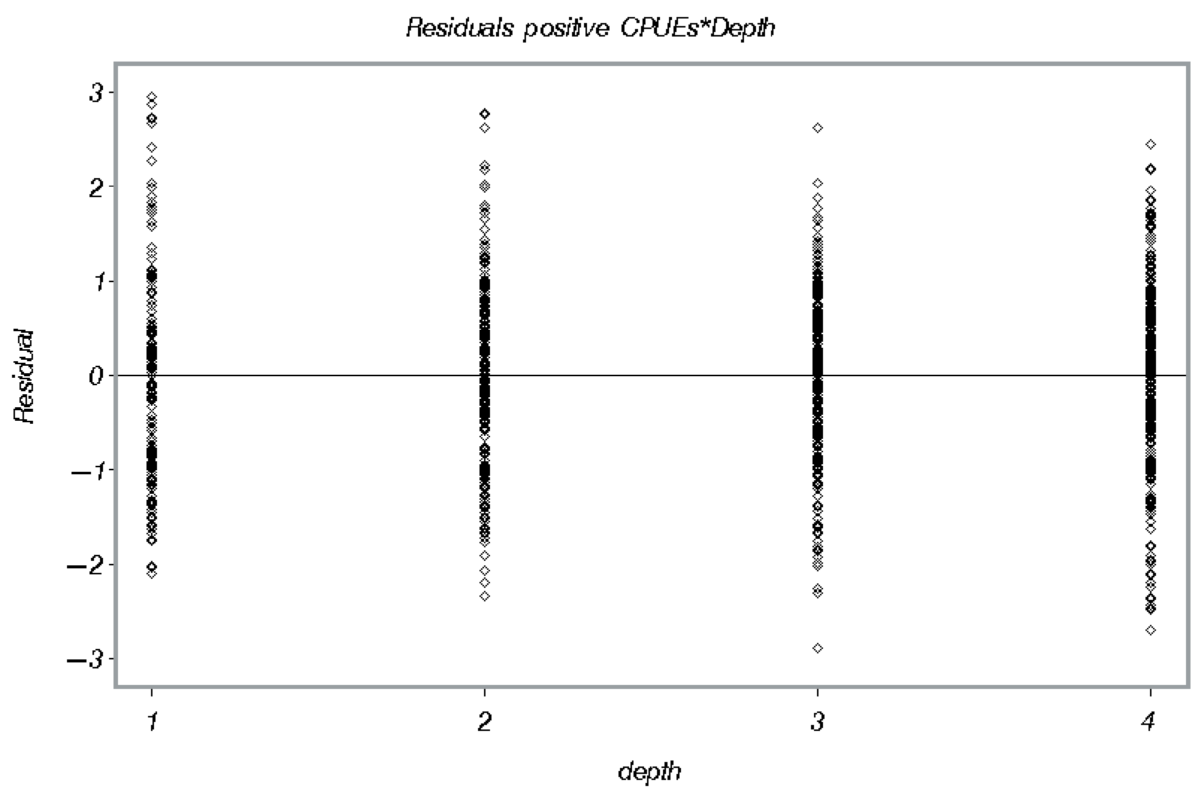
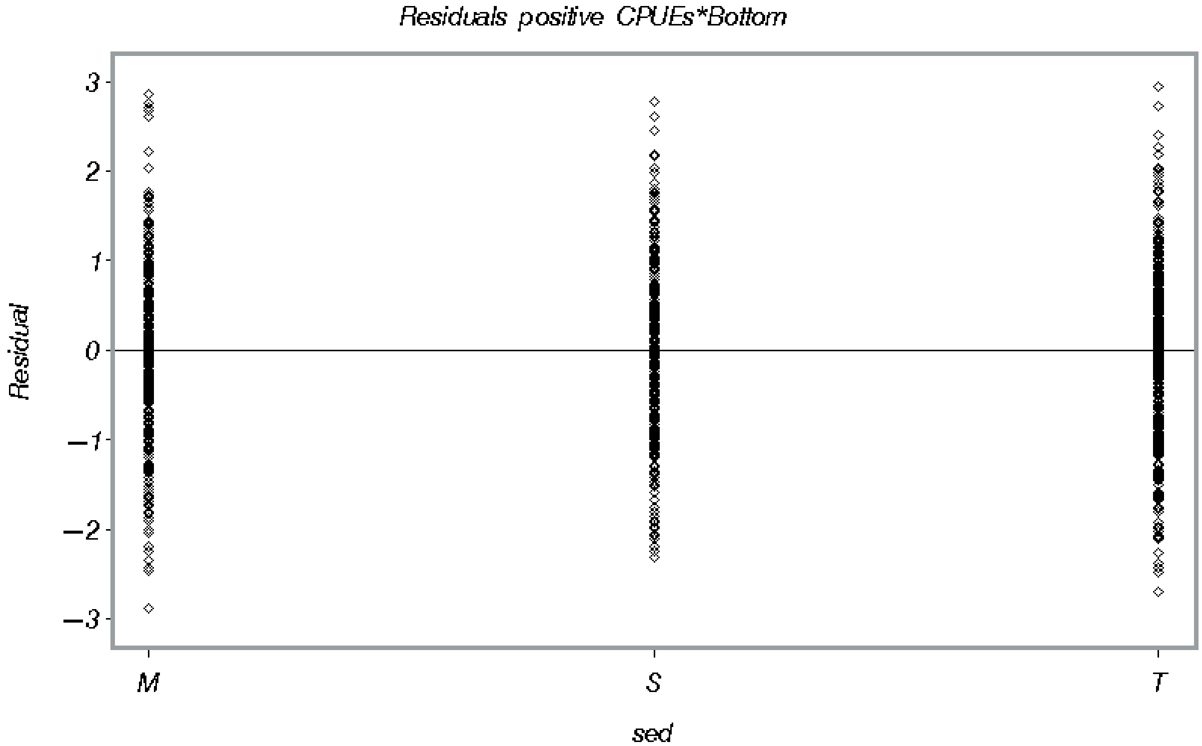


Figure 2b continued. LIS smooth dogfish model diagnostic plots for lognormal component.



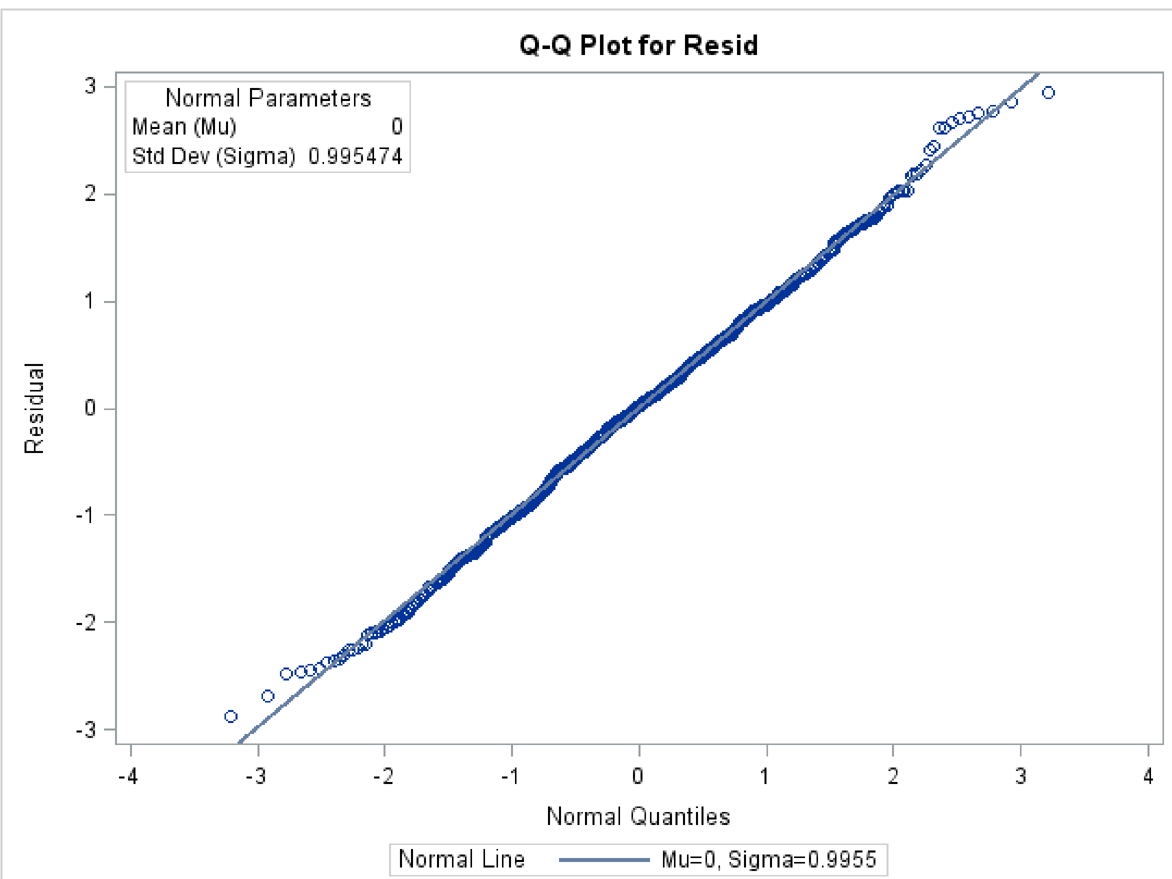


Figure 3. LIS smooth dogfish nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCI0, UCI0).

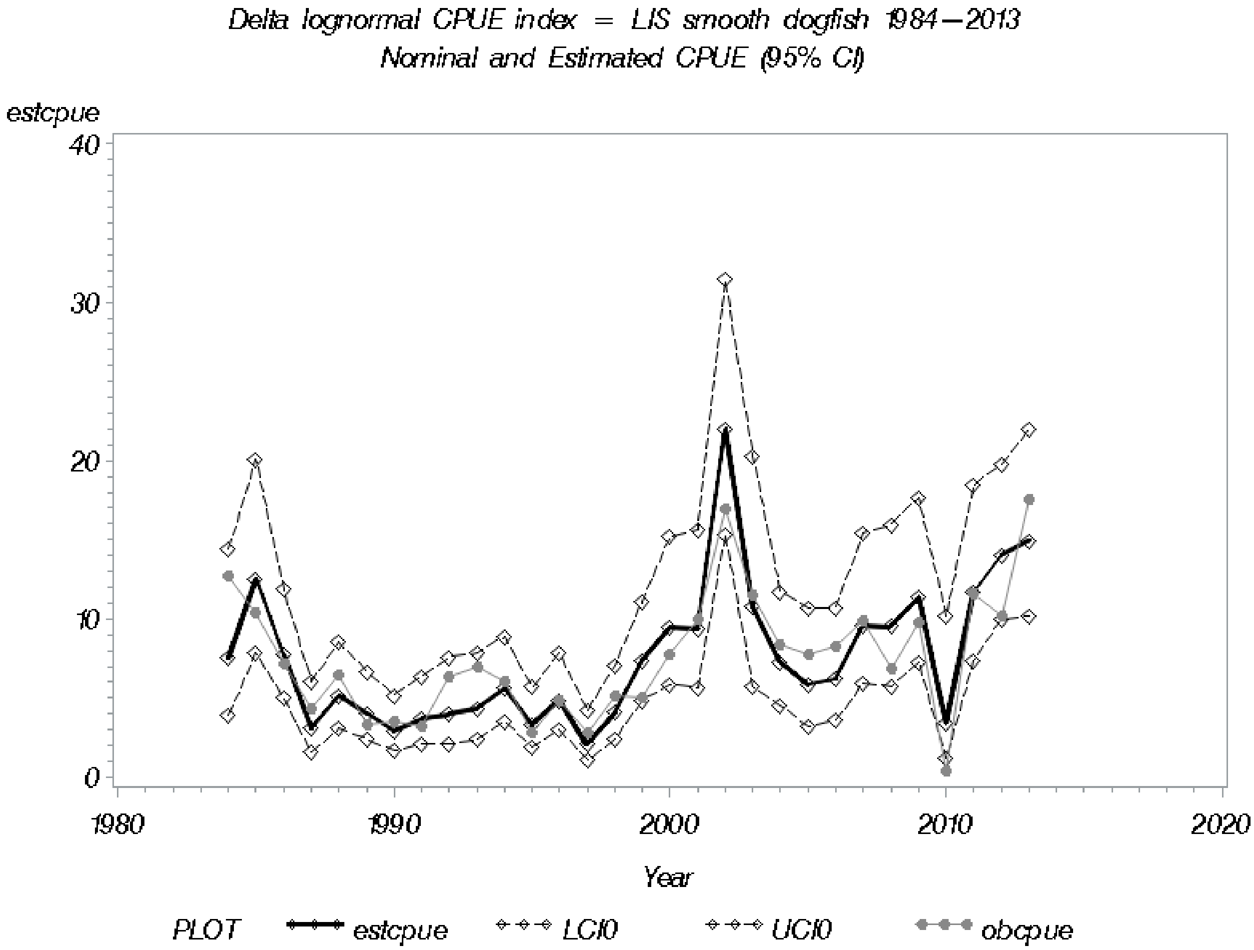
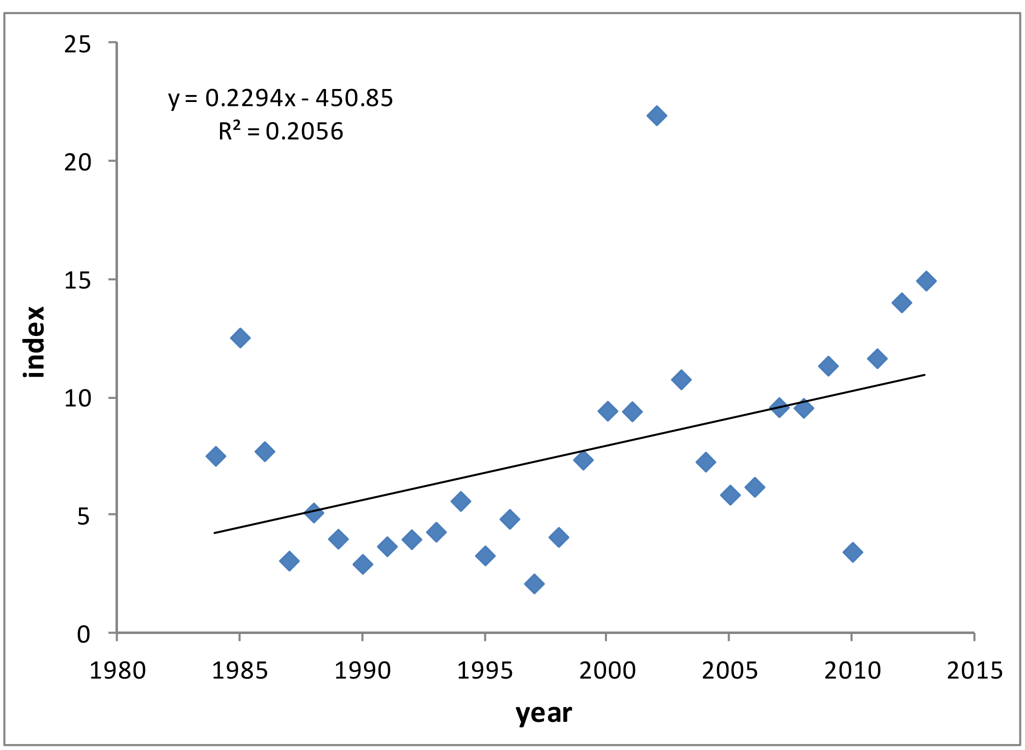


Figure 4. Plot of the standardized index of abundance over time with a linear trend line



ADDENDUM TO SEDAR39-DW-12

Based on the length of the catch time series that will be used in the assessment model the Long Island Sound trawl time series needed to be run through the standardization process (delta-lognormal model) using the factors from the original model with an end date of 2012. The resulting index values and trends are reported below.

Table A1. 1984-2012 LIS trawl survey smooth dogfish analysis number of tows (n tows), number of sharks (catch), 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 catch per 30 minute tow (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 tows	catch	n obs	obs pos	obs ppos	obs cpue	est cpue	LCL	UCL
1984	102	534	42	25	0.5952	12.7143	7.5953	4.0256	14.3307
1985	126	405	39	30	0.7692	10.3846	12.4479	7.8467	19.7472
1986	196	430	60	38	0.6333	7.1667	7.6799	5.0511	11.6769
1987	200	257	60	24	0.4000	4.2833	3.1205	1.6051	6.0666
1988	200	385	60	33	0.5500	6.4167	5.1414	3.1198	8.4729
1989	200	202	60	33	0.5500	3.3667	4.0012	2.4295	6.5897
1990	200	209	60	30	0.5000	3.4833	2.9468	1.6982	5.1135
1991	200	193	60	31	0.5167	3.2167	3.6796	2.1569	6.2775
1992	160	304	48	26	0.5417	6.3333	4.0255	2.1526	7.5278
1993	240	420	60	28	0.4667	7.0000	4.3384	2.4085	7.8148
1994	240	361	60	36	0.6000	6.0167	5.5643	3.5490	8.7241
1995	200	168	60	31	0.5167	2.8000	3.3039	1.9378	5.6332
1996	200	275	57	35	0.6140	4.8246	4.8321	3.0334	7.6974
1997	200	167	60	24	0.4000	2.7833	2.1426	1.1018	4.1665
1998	200	310	60	31	0.5167	5.1667	4.0753	2.3898	6.9497
1999	200	305	60	39	0.6500	5.0833	7.2817	4.8587	10.9130
2000	200	467	60	35	0.5833	7.7817	9.3924	5.8962	14.9617
2001	200	598	60	33	0.5500	9.9583	9.4330	5.7271	15.5368
2002	200	1019	60	43	0.7167	16.9850	21.7208	15.2732	30.8903
2003	160	552	48	23	0.4792	11.5042	10.7015	5.7505	19.9153
2004	199	503	60	35	0.5833	8.3867	7.2413	4.5457	11.5356
2005	200	467	60	28	0.4667	7.7767	5.9285	3.2928	10.6739
2006	120	332	40	28	0.7000	8.3000	6.1641	3.6156	10.5090
2007	200	580	59	35	0.5932	9.8339	9.6018	6.0241	15.3045
2008	160	328	48	27	0.5625	6.8292	9.4524	5.7158	15.6319
2009	200	588	60	37	0.6167	9.8000	11.2284	7.2748	17.3307
2010	78	10	24	5	0.2083	0.4208	3.2974	1.1360	9.5711
2011	172	613	53	36	0.6792	11.5679	11.5605	7.3709	18.1314
2012	200	610	60	45	0.7500	10.1733	13.8712	9.9186	19.3990

Figure A1. 1984-2012 LIS trawl survey smooth dogfish nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCI0, UCI0).