Standardized indices of abundance for Smooth Dogfish, *Mustelus canis*, from the University of Rhode Island trawl survey conducted by the Graduate School of Oceanography

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SEDAR 39 DATA WORKSHOP DOCUMENT

Standardized indices of abundance for Smooth Dogfish, *Mustelus canis*, from the University of Rhode Island trawl survey conducted by the Graduate School of Oceanography

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Summary

This document details the smooth dogfish catch from the University of Rhode Island (URI) trawl survey conducted by the Graduate School of Oceanography from 1959-2013. 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 shows an overall decreasing trend in relative abundance through the 1990s followed by a peak in abundance in 2003 and then a gradual increasing trend at the end of time series. The 2003 peak in abundance is also seen in the time series for the monthly and seasonal trawl surveys conducted by the Rhode Island Department of Environmental Management in the same area as the URI trawl survey.

Introduction

The University of Rhode Island Graduate School of Oceanography Fish Trawl Survey is a state funded survey of the bottom fish and invertebrate community in Narragansett Bay, Rhode Island. The survey was initiated in 1959 by Charles J. Fish, founder and director of the Narragansett Marine Laboratory, the precursor to the Graduate School of Oceanography. The Fish Trawl Survey was developed to quantify the seasonal occurrences of migratory fish populations, whereas scientists had previously relied on anecdotal information. In this document, the URI trawl time series is modeled to create a standardized index of abundance for smooth dogfish.

Methods

Sampling gear and survey design

One morning per week, year round, the Graduate School of Oceanography Fish Trawl Survey samples two fixed locations in Narragansett Bay using a 2-seam otter trawl with bag. The survey net consists of 3-inch (7.6-cm) stretch mesh in the wings and body, and 2-inch (5.1-cm) stretch mesh in the cod end. The trawl has a 39-foot (11.9-m) headrope and 48-inch x 24-inch (1.24-m x 0.61-m) steel doors. The distance from the otter boards to the net is 60 ft (18.3 m) and the distance between otter boards while fishing is 52 ft (15.8 m) at the Fox Island station and 64.5 ft (19.7 m) at the Whale Rock station. The Fox Island station is located in Narragansett Bay adjacent to Quonset Point and Wickford, Rhode Island at 41°34.5' N, 71°24.3'W in 20 ft (7.9 m) of water over soft mud and shell debris. The Whale Rock station is located at the mouth of the West Passage in Narragansett Bay at 41°26.3' N, 71°25.4'W in 65 ft (19.8 m) of water over course mud and fine sand. The net is towed at 2 knots for 30 minutes at each station. The number and weight of each species captured is recorded.

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 URI trawl survey. 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 (1959-2013), month (May - November), and station (Fox Island, Whale Rock). The proportion of tows 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 1342 smooth dogfish were caught during 3061 tows from 1959 to 2013. The proportion of tows with positive catch (at least one smooth dogfish was caught) was 18%. 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 1a and 1b). 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 2. The nominal and standardized relative abundance for smooth dogfish shows an overall decreasing trend in relative abundance through the 1990s followed by a peak in abundance in 2003 and then a gradual increasing trend at the end of time series. The 2003 peak in abundance is also seen in the time series for the monthly and seasonal trawl surveys conducted by the Rhode Island Department of Environmental Management in the same area as the URI trawl survey (McCandless and Olszewski 2014).

Acknowledgement

Gratitude is extended to the University of Rhode Island's Graduate School of Oceanography for providing the data collected during their biweekly trawl survey for use in these analyses.

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Table 1. Results of the stepwise procedure for development of the URI 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	765	1026.5159	1.3419		
MONTH	759	910.5183	1.1996	10.6044	10.6044
YEAR	711	861.9816	1.2124	9.6505	
STATION	764	1021.2494	1.3367	0.3875	
MONTH +					
YEAR	705	716.2779	1.0160	24.2865	13.6821

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
MONTH + YEAR	3556.5	3561.0	3554.5

Type 3 Test of Fixed Effects

Significance (Pr>Chi) of Type 3	MONTH	YEAR
test of fixed effects for each factor	<.0001	<.0001
DF	6	52
CHI SQUARE	92.64	107.42

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%
NULL	300	283.0497	0.9435		
YEAR	248	189.4844	0.7640	19.0249	19.0249
STATION	299	256.6663	0.8584	9.0196	
MONTH	294	267.7481	0.9107	3.4764	
YEAR +					
STATION	247	169.9971	0.6882	27.0588	8.0339
MONTH	242	172.1541	0.7114	24.5999	5.5750
YEAR + STATION +					
MONTH	241	156.223	0.6482	31.2984	4.2395

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
YEAR + STATION + MONTH	688.1	691.6	686.1

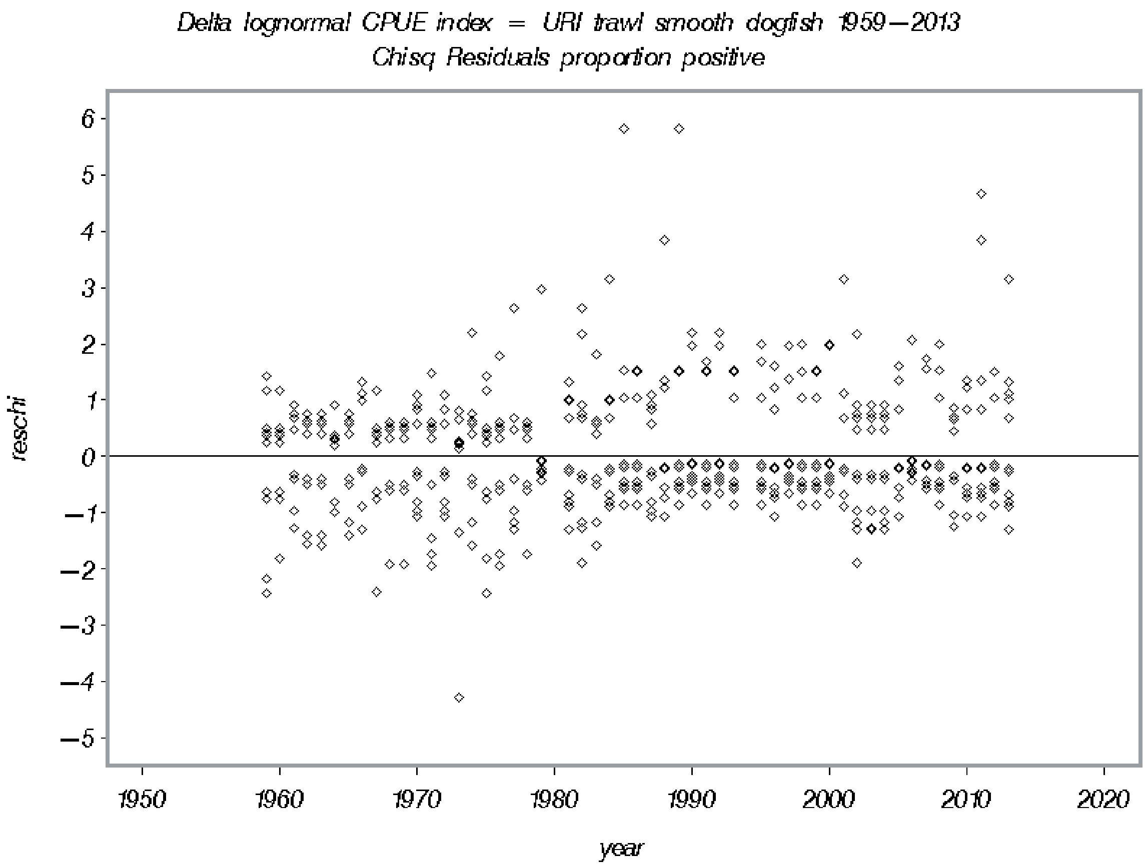
Type 3 Test of Fixed Effects

Significance (Pr>Chi) of Type 3	YEAR	STATION	MONTH
test of fixed effects for each factor	<.0001	<.0001	0.0022
DF	52	1	6
CHI SQUARE	136.97	24.58	21.25

Table 2. URI trawl survey smooth dogfish analysis number of tows (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
1959	60	94	14	10	0.7143	6.7143	5.3399	2.7712	10.2899	0.3370
1960	58	44	14	10	0.7143	3.1429	3.1786	1.6510	6.1194	0.3365
1961	60	40	14	7	0.5000	2.8571	2.6412	1.0281	6.7854	0.4993
1962	57	51	14	8	0.5714	3.6429	2.9109	1.2571	6.7405	0.4390
1963	55	37	14	8	0.5714	2.6429	2.5597	1.1057	5.9258	0.4389
1964	59	32	14	11	0.7857	2.2857	2.7364	1.5327	4.8853	0.2960
1965	60	22	14	8	0.5714	1.5714	1.6471	0.7115	3.8129	0.4389
1966	56	23	14	5	0.3571	1.6429	0.9813	0.3011	3.1982	0.6462
1967	54	50	14	10	0.7143	3.5714	3.8597	2.0044	7.4322	0.3366
1968	46	32	14	9	0.6429	2.2857	2.2543	1.0726	4.7378	0.3845
1969	54	64	14	9	0.6429	4.5714	4.1923	1.9945	8.8123	0.3846
1970	56	57	14	6	0.4286	4.0714	3.7124	1.2940	10.6506	0.5658
1971	56	116	14	9	0.6429	8.2857	6.4726	3.0679	13.6556	0.3867
1972	45	62	14	6	0.4286	4.4286	3.5097	1.2221	10.0793	0.5664
1973	48	52	14	12	0.8571	3.7143	3.9243	2.3263	6.6197	0.2660
1974	49	43	14	8	0.5714	3.0714	3.0738	1.3263	7.1238	0.4395
1975	52	41	14	10	0.7143	2.9286	3.5620	1.8480	6.8658	0.3371
1976	47	25	14	9	0.6429	1.7857	2.1506	1.0227	4.5225	0.3849
1977	47	32	14	7	0.5000	2.2857	2.6398	1.0189	6.8393	0.5043
1978	52	14	14	9	0.6429	1.0000	1.3239	0.6300	2.7820	0.3845
1979	54	4	14	1	0.0714	0.2857	0.2541	0.0293	2.2072	1.4886
1980	50	0	14	0	0	0	.	.	.	.
1981	44	10	14	5	0.3571	0.7143	0.8348	0.2569	2.7130	0.6443
1982	48	24	14	7	0.5000	1.7143	2.0608	0.7992	5.3139	0.5014
1983	44	35	14	8	0.5714	2.5000	2.1127	0.9122	4.8930	0.4391
1984	54	45	14	5	0.3571	3.2143	1.9472	0.5982	6.3380	0.6454
1985	57	3	14	3	0.2143	0.2143	0.3943	0.0872	1.7827	0.8756
1986	55	4	14	3	0.2143	0.2857	0.3039	0.0677	1.3640	0.8700
1987	61	10	14	6	0.4286	0.7143	0.8889	0.3099	2.5496	0.5656
1988	59	4	14	4	0.2857	0.2857	0.4096	0.1087	1.5439	0.7436
1989	62	3	14	3	0.2143	0.2143	0.2852	0.0631	1.2881	0.8748
1990	59	3	14	2	0.1429	0.2143	0.2422	0.0420	1.3948	1.0733
1991	54	3	14	3	0.2143	0.2143	0.3085	0.0686	1.3877	0.8717
1992	59	2	14	2	0.1429	0.1429	0.1322	0.0230	0.7606	1.0722
1993	62	3	14	3	0.2143	0.2143	0.2866	0.0637	1.2884	0.8713
1994	61	0	14	0	0	0	.	.	.	.
1995	62	3	14	3	0.2143	0.2143	0.2089	0.0465	0.9378	0.8703
1996	60	5	14	4	0.2857	0.3571	0.5094	0.1355	1.9152	0.7419
1997	60	2	14	2	0.1429	0.1429	0.1184	0.0206	0.6805	1.0717
1998	62	6	14	3	0.2143	0.4286	0.4444	0.0988	1.9989	0.8717
1999	52	3	14	3	0.2143	0.2143	0.2866	0.0637	1.2884	0.8713
2000	60	2	14	2	0.1429	0.1429	0.1426	0.0248	0.8202	1.0721
2001	60	17	14	5	0.3571	1.2143	1.3453	0.4127	4.3860	0.6464
2002	54	20	14	7	0.5000	1.4286	1.6171	0.6298	4.1523	0.4990
2003	57	115	14	7	0.5000	8.2143	5.7018	2.2225	14.6279	0.4985
2004	62	23	14	7	0.5000	1.6429	1.1176	0.4356	2.8670	0.4984
2005	59	6	14	4	0.2857	0.4286	0.4956	0.1317	1.8652	0.7425
2006	60	2	14	1	0.0714	0.1429	0.0709	0.0082	0.6154	1.4882
2007	60	2	12	2	0.1667	0.1667	0.1531	0.0278	0.8422	1.0335
2008	58	7	14	3	0.2143	0.5000	0.4224	0.0939	1.9010	0.8721
2009	43	6	12	6	0.5000	0.5000	0.7253	0.2713	1.9391	0.5230
2010	61	8	14	4	0.2857	0.5714	0.4254	0.1133	1.5964	0.7406
2011	60	8	14	4	0.2857	0.5714	0.9177	0.2431	3.4640	0.7446
2012	58	4	14	3	0.2143	0.2857	0.2739	0.0609	1.2325	0.8720
2013	59	19	14	5	0.3571	1.3571	1.0533	0.3238	3.4258	0.6449

Figure 1a. URI trawl survey smooth dogfish model diagnostic plots for the binomial component.



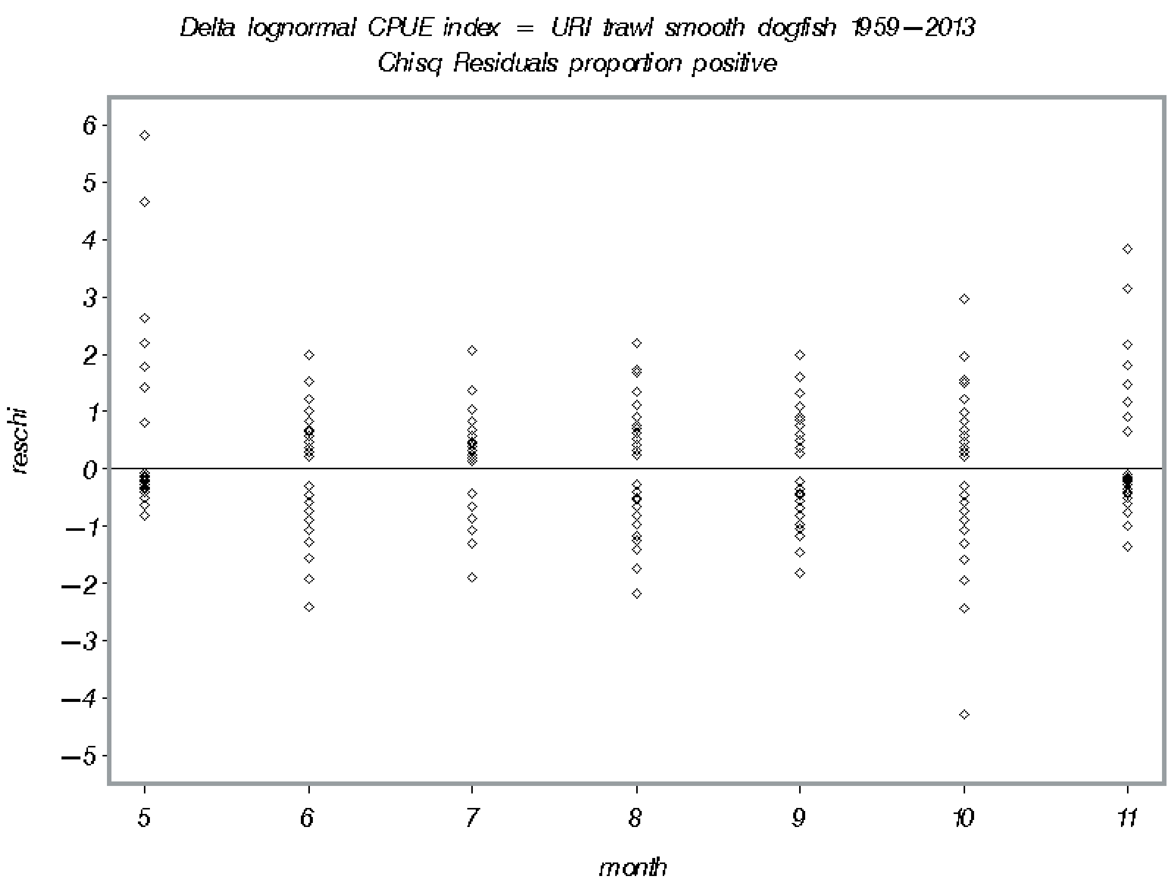


Figure 1a continued. URI trawl survey smooth dogfish model diagnostic plots for the binomial component.

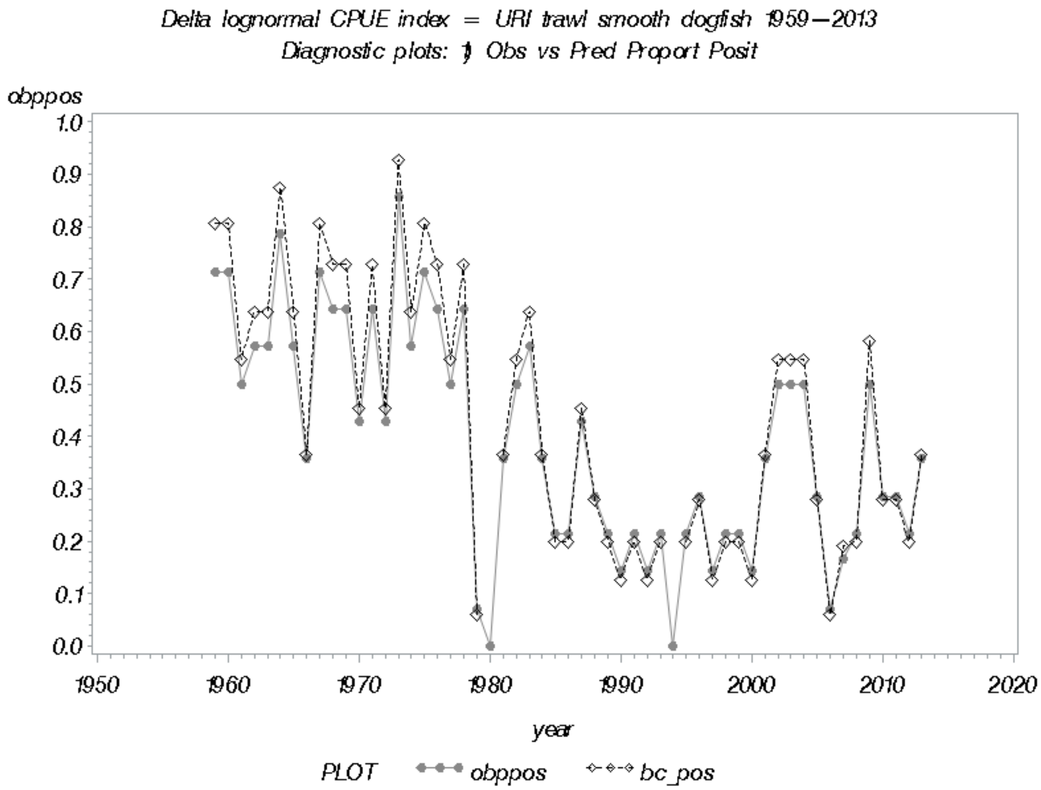


Figure 1b. URI trawl survey smooth dogfish model diagnostic plots for lognormal component.

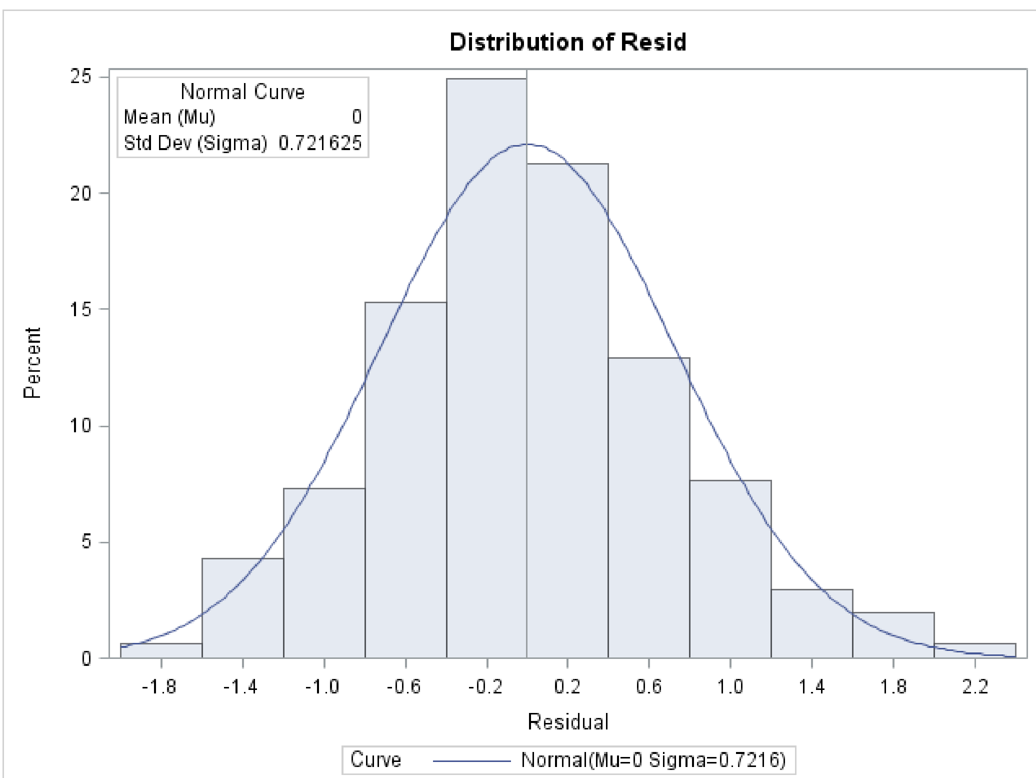
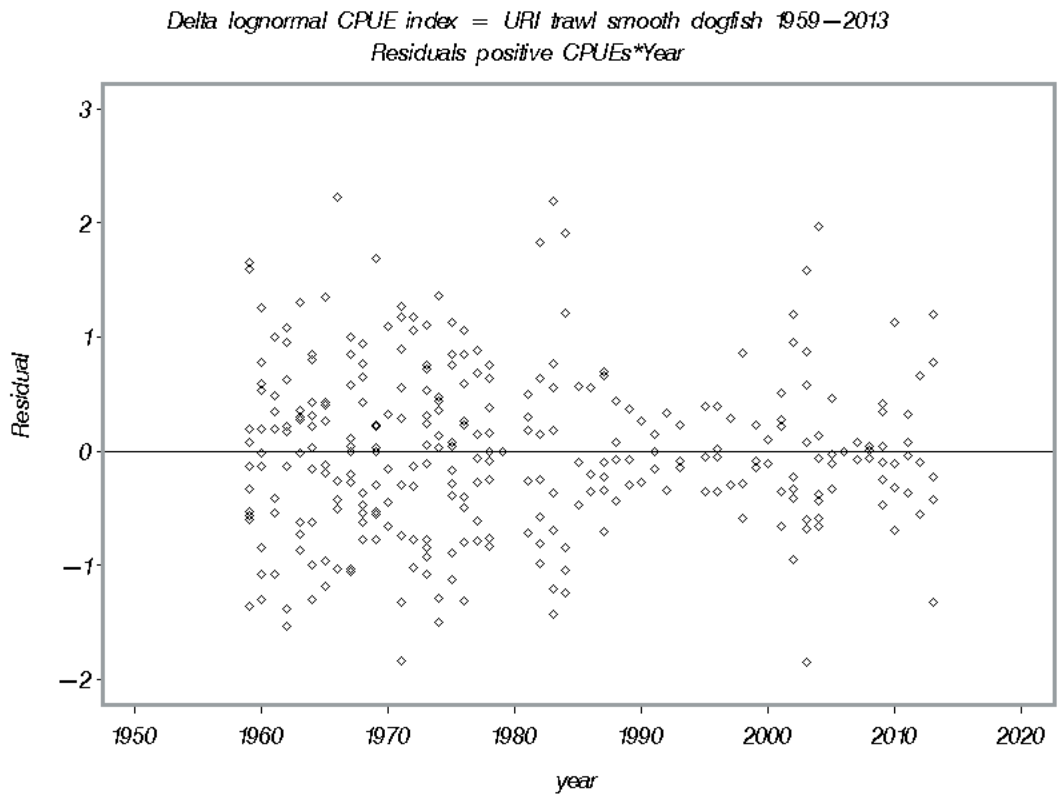


Figure 1b continued. URI trawl survey smooth dogfish model diagnostic plots for lognormal component.



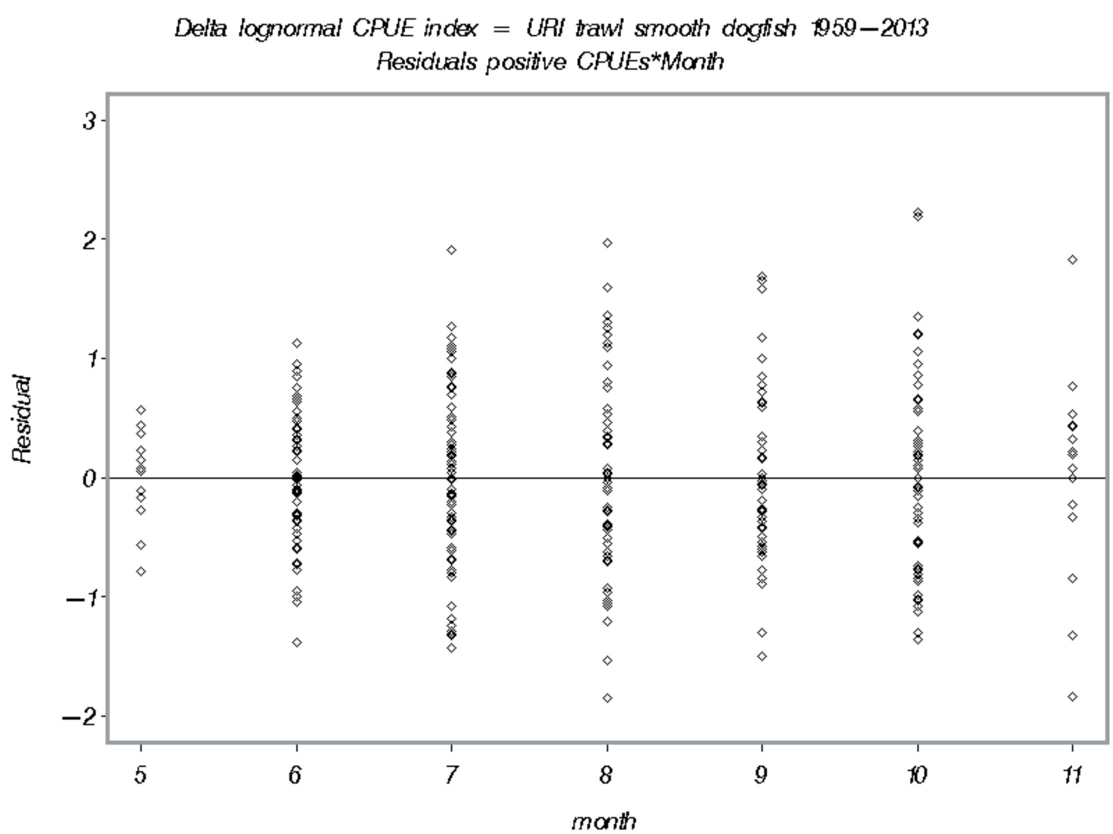
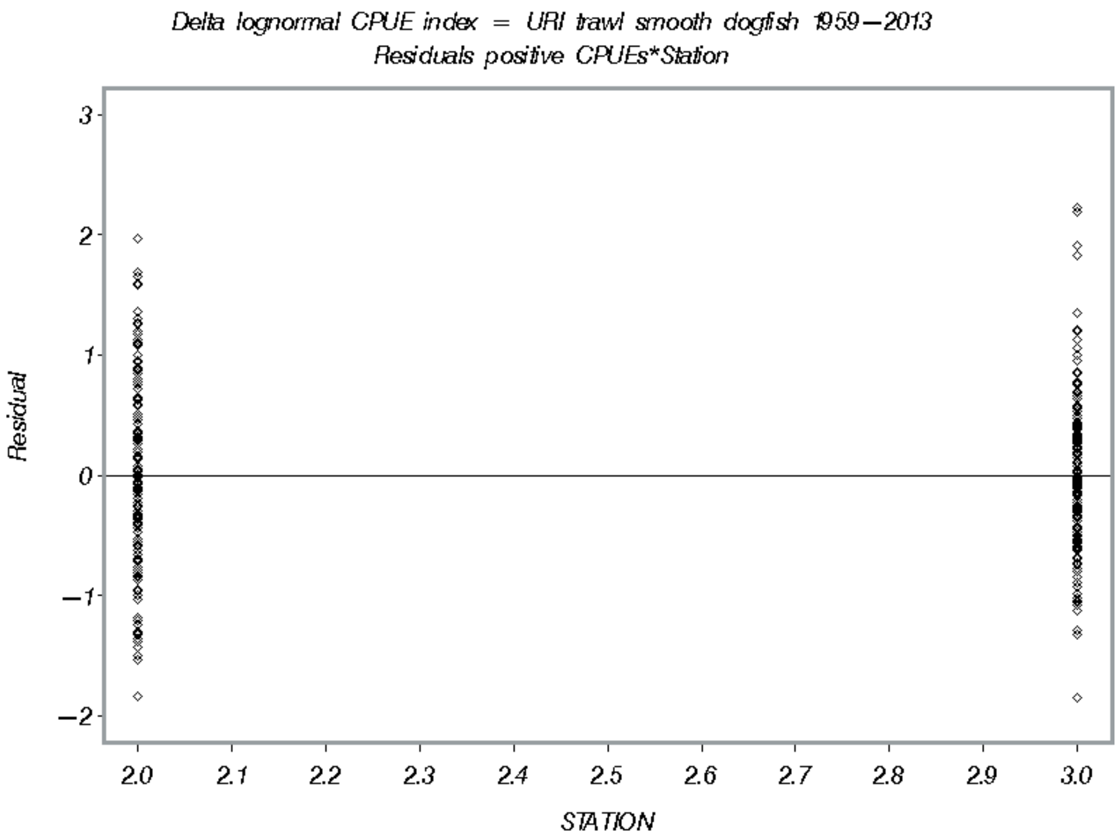


Figure 1b continued. URI trawl survey smooth dogfish model diagnostic plots for lognormal component.



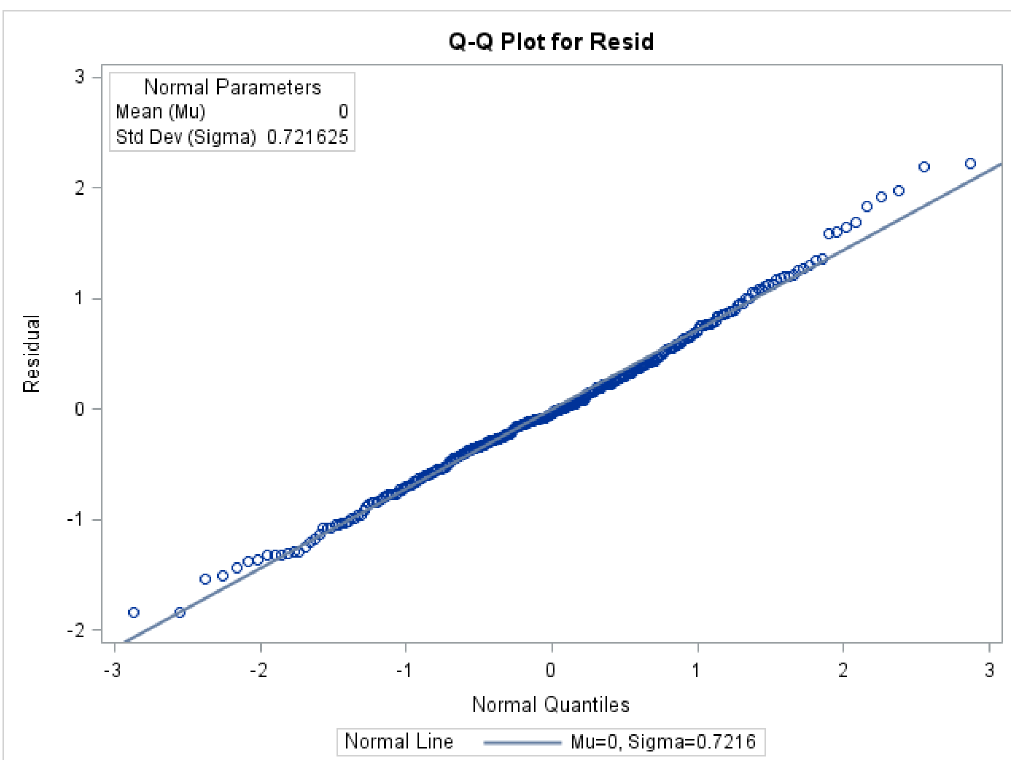


Figure 2. URI trawl survey smooth dogfish nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCI0, UCI0).