Standardized catch rates for sandbar sharks from the NMFS Northeast Longline Survey

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SEDAR 101 DATA WORKSHOP DOCUMENT

Standardized catch rates for sandbar sharks from the NMFS Northeast Longline Survey

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Summary

This document details sandbar shark catches from the Northeast Fisheries Science Center (NEFSC) coastal shark bottom longline survey, conducted by the Apex Predators Program, Narragansett Laboratory, Narragansett, RI from 1996-2024. Data from this survey were used to look at the trends in relative abundance of sandbar sharks in the waters off the east coast of the United States. Catch per unit effort (CPUE) by set in number of sharks per 100 hook-hours were examined for each year of the bottom longline survey, 1996, 1998, 2001, 2004, 2007, 2009, 2012, 2015, 2018, 2021, and 2024. The CPUE was standardized using the delta-lognormal approach, which 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 show an increasing trend in relative abundance across the time series.

Introduction

The Northeast Fisheries Science Center (NEFSC) coastal shark bottom longline survey is conducted by the Apex Predators Program, Narragansett Laboratory, Narragansett, RI. The primary objective of this survey is to conduct a standardized, systematic survey of the shark populations off the US Atlantic coast to provide unbiased indices of the relative abundance for species inhabiting the waters from Florida to the Mid-Atlantic. It also provides an opportunity to tag sharks as part of the NEFSC Cooperative Shark Tagging Program and to collect biological samples and data used in analyses of life history characteristics (age, growth, reproductive biology, trophic ecology, etc.) and other research of sharks in US coastal waters. Standardized relative abundance indices from this survey have been previously generated for sandbar sharks (SEDAR 11, SEDAR 21, and SEDAR 54). In this document, the time series is updated with data through 2024.

Methods

Sampling Gear and Data Collection

For information on the sampling gear and data collection methods used by the NEFSC during this coastal shark bottom longline survey see the previous SEDAR working documents, LCS05/06-DW33 and SEDAR21-DW28, or the additional working document during this SEDAR process on spatiotemporal methods (SEDAR101-DW26).

Data Analysis

Catch per unit effort (CPUE) for each set is defined as the number of sharks per hook hour. The CPUE was standardized using the delta-lognormal method, which models the proportion of positive sets separately from the positive catch (Lo et al. 2002). Factors considered as potential influences on CPUE were: year (1996, 1998, 2001, 2004, 2007, 2009, 2012, 2015, 2018, 2021, 2024), month (April, May), area (1 = <33.8 º latitude, 2 = 33.8 to 35.7 º latitude, 3 = > 35.7 º latitude), depth (<20, 20-29, 30-39, 40-49, 50+ m), and surface water temperature (<21, 21+ deg C). 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 providing 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 9886 sandbar sharks were caught during 649 longline sets from 1996 to 2024. Sandbar sharks ranged in size from 62 to 213 cm FL (see SEDAR101-DW26, Figure 3, for annual size ranges by sex). The proportion of sets with positive catch (at least one sandbar shark caught) across the time series is 67%. 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 1 and 2). 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 3. A plot of the index re-modeled after removing the last year, 5 consecutive times, is located in Figure 4 for retrospective analysis.

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Table 1. Results of the stepwise procedure for development of the NEFSC LL catch rate model of sandbar sharks for 1996-2024 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	196	475.8445	2.4278				
year	186	336.6455	1.8099	25.451		139.2	<.0001
area	194	404.7856	2.0865	14.058		71.06	<.0001
depth	193	455.636	2.3608	2.760		20.21	0.0002
month	195	462.6553	2.3726	2.274		13.19	0.0003
temp	195	475.5485	2.4387	-0.449		0.3	0.5864
YEAR +							
area	184	272.3303	1.4801	39.035	13.584	64.32	<.0001
month	185	279.6717	1.5117	37.734	12.283	56.97	<.0001
depth	183	303.8192	1.6602	31.617	6.166	32.83	<.0001
YEAR + AREA							
month	183	233.6257	1.2766	47.417	8.382	38.7	<.0001
depth	181	243.2255	1.3438	44.649	5.614	29.1	<.0001
YEAR + AREA + MONTH							
depth	180	187.0429	1.0391	57.200	9.783	46.58	<.0001
YEAR + AREA + MONTH + DEPTH +							
month*dept	177	161.1579	0.9105	62.497	5.297	25.88	<.0001
area*depth	174	159.8478	0.9187	62.159	4.959	27.2	0.0001
year*area	164	156.5182	0.9544	60.689	3.489	negative hessian	
year*month	170	178.1580	1.0480	56.833	-0.367	negative hessian	
year*depth	150	158.8266	1.0588	56.388	-0.811	negative hessian	
area*month	179	185.2122	1.0347	57.381	0.181	1.83	0.1760
YEAR + AREA + MONTH + DEPTH + MONTH*DEPTH							
area*depth	171	149.3932	0.8736	64.017	1.520	11.76	0.0674

FINAL MODEL: YEAR + AREA + MONTH + DEPTH + MONTH*DEPTH

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

Significance (Pr>Chi) of Type 3	year	area	month	depth	month*depth
test of fixed effects for ea. factor	<.0001	<.0001	<.0001	<.0001	<.0001
DF	10	2	1	3	3
CHI SQUARE	118.47	46.36	37.74	43.54	30.23

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE	%DIFF	DELTA%	CHISQ	PR>CHI
null	429	842.1423	1.9630				
year	419	461.9113	1.1024	43.84106		258.25	<.0001
temp	428	818.3488	1.9120	2.598064		12.32	0.0004
depth	426	834.9086	1.9599	0.157922		3.71	0.2946
month	428	841.8788	1.9670	-0.20377		0.13	0.7137
YEAR +							
temp	418	461.9049	1.105	12.27399	-31.5671	0.01	0.9386

FINAL MODEL: YEAR

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

Significance (Pr>Chi) of Type 3	year
test of fixed effects for each factor	<.0001
DF	10
CHI SQUARE	341.37

Table 2. Sandbar shark analysis 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 delta-lognormal 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	obcpue	estcpue	LCL	UCL	CV
1996	89	33	0.3708	0.0559	0.0361	0.0181	0.0723	0.3571
1997								
1998	84	46	0.5476	0.4376	0.2411	0.1360	0.4271	0.2920
1999								
2000								
2001	84	45	0.5357	0.2207	0.1151	0.0649	0.2043	0.2927
2002								
2003								
2004	67	31	0.4627	0.1431	0.0943	0.0468	0.1899	0.3610
2005								
2006								
2007	22	19	0.8636	0.5997	0.7396	0.4411	1.2401	0.2628
2008								
2009	49	43	0.8776	1.0716	1.1133	0.7767	1.5959	0.1815
2010								
2011								
2012	48	38	0.7917	1.2644	1.4632	0.9547	2.2426	0.2159
2013								
2014								
2015	49	43	0.8776	1.8972	2.5316	1.7837	3.5933	0.1765
2016								
2017								
2018	53	49	0.9245	1.5645	1.8216	1.3068	2.5391	0.1672
2019								
2020								
2021	51	45	0.8824	1.9192	3.0397	2.1464	4.3048	0.1753
2022								
2023								
2024	43	40	0.9302	1.7964	2.4306	1.7112	3.4523	0.1768

Figure 1. Diagnostic plots for the **binomial component** of the NEFSC LL catch rate model for sandbar sharks.

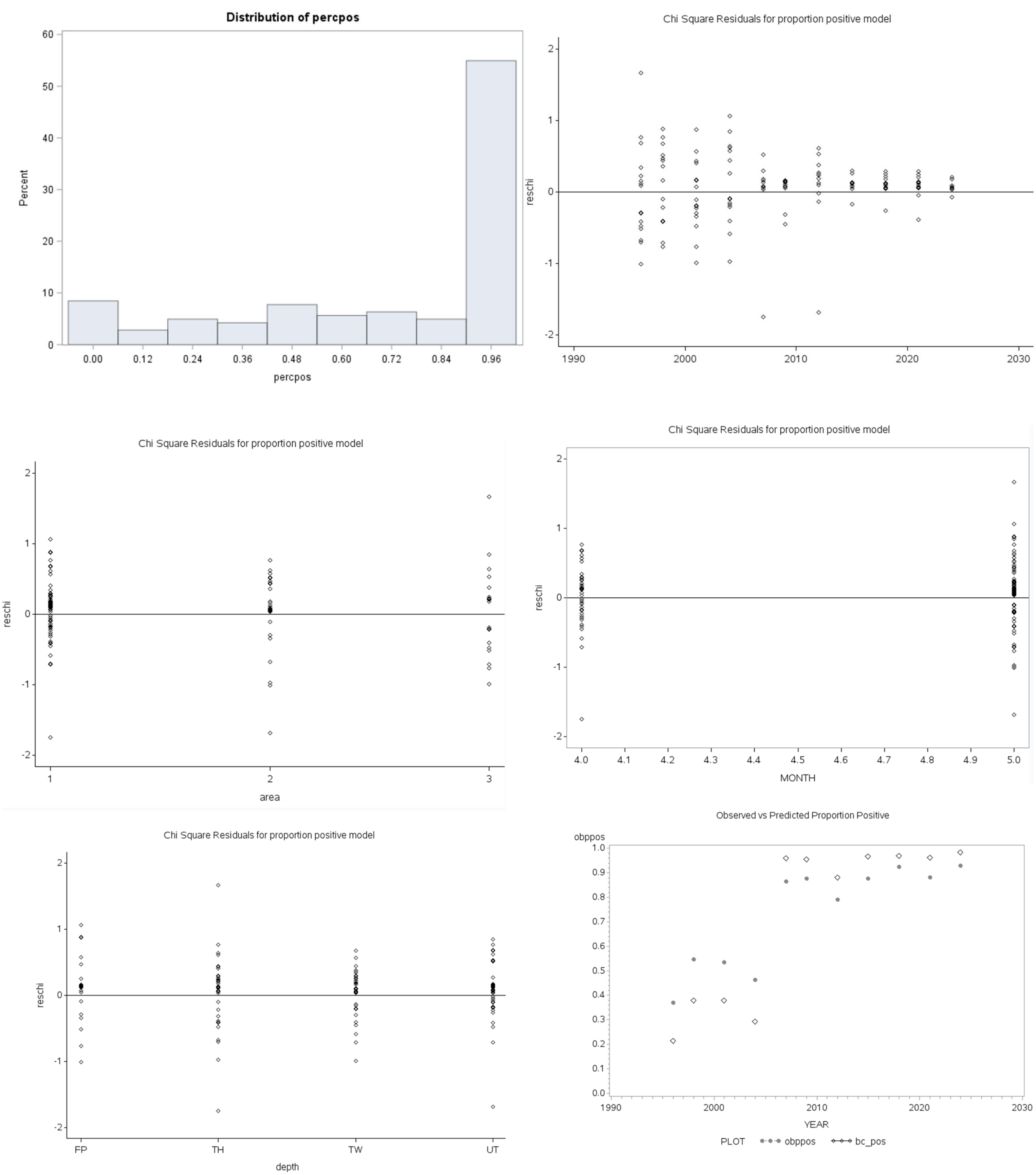

Figure 2. Diagnostic plots for the **lognormal component** of the NEFSC catch rate model for sandbar sharks.

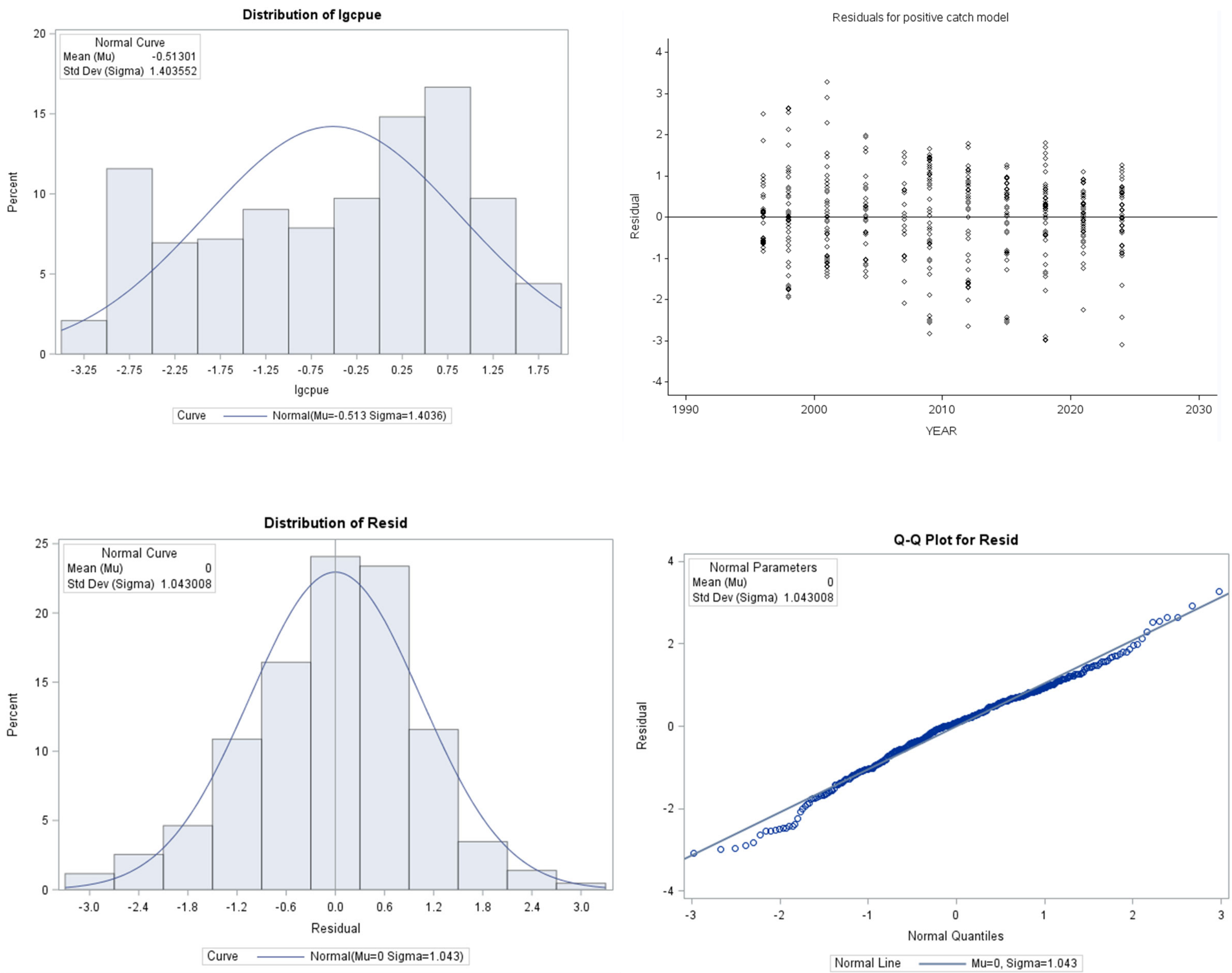

Figure 3. NEFSC LL index for sandbar shark relative abundance (estcpue) with 95% confidence interval (dotted lines) and overlayed with the nominal catch-per-unit-effort data (obcpue).

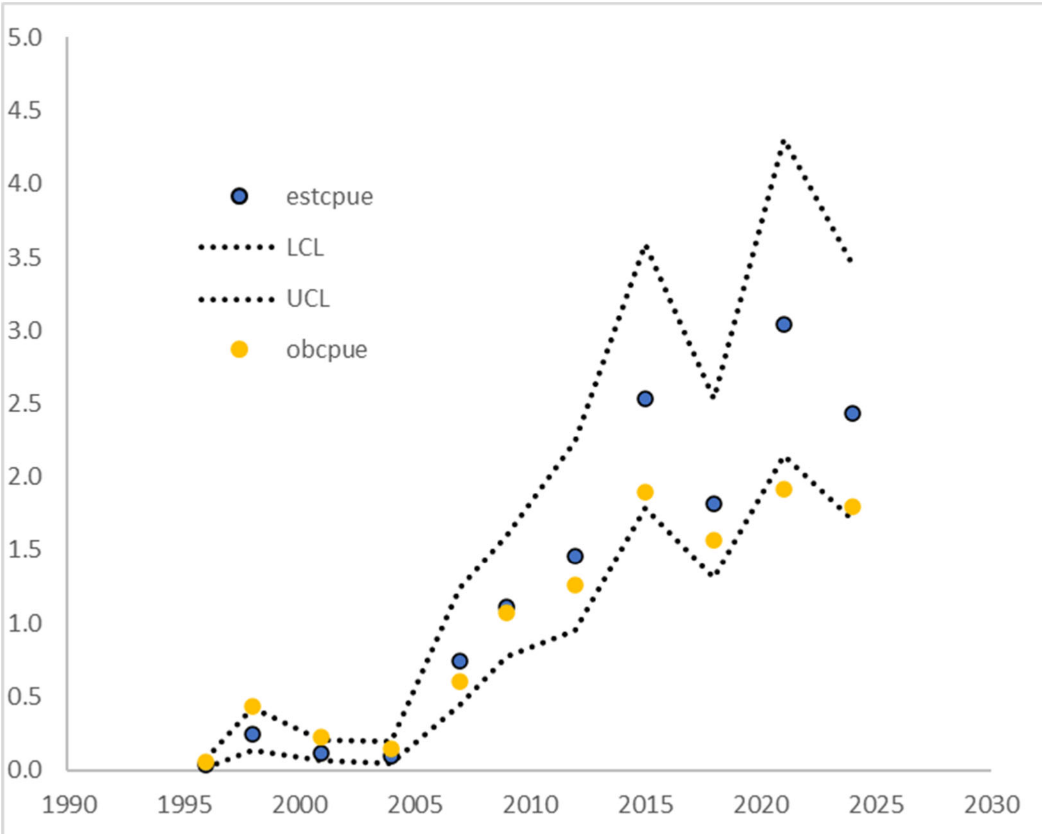

Figure 4. Retrospective analysis