Hierarchical analysis of U.S Atlantic smooth dogfish and Gulf of Mexico smoothhound species indices of abundance

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SEDAR 39 ASSESSMENT WORKSHOP DOCUMENT

Hierarchical analysis of U.S Atlantic smooth dogfish and Gulf of Mexico smoothhound species indices of abundance

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Summary

This document details the hierarchical trends for both smooth dogfish indices of abundance recommended for the U.S. Atlantic and smoothhound species indices of abundance recommended for the Gulf of Mexico during the SEDAR 39 Data Workshop. For each area (U.S. Atlantic and Gulf of Mexico) the recommended indices (standardized to their means) and coefficients of variation were used in a hierarchical analysis to estimate individual index process error, assuming a lognormal error structure, and a hierarchical index of abundance. Hierarchical analysis results indicated that, when present, the NEFSC autumn bottom trawl survey appears to drive the overall trend for the hierarchical analysis resulting in a decreasing trend in recent years. Results using only state survey data, which, although smaller in scale, in combination may better represent Atlantic smooth dogfish abundance, indicated an uptick in abundance in recent years. Hierarchical analysis of the Gulf of Mexico smoothhound indices indicated an overall increasing trend in abundance and very little process variation across individual surveys, providing supporting evidence that the standardization process used to develop the survey indices did a good job of modeling the population trend by just modeling sampling error alone.

Introduction

Hierarchical analysis has been used in past shark assessments (Conn 2010a, SEDAR 2012, SEDAR 2013a, SEDAR 2013b) to provide an overall abundance trend for multiple standardized indices of abundance. The standardization process is expected to capture the sampling error associated with each index of abundance, but does not account for the degree to which an index may measure ‘artifacts’ not related to the relative abundance of the entire population, referred to as process error (Conn 2010a, Conn 2010b). Process error can account for the variability in trends across multiple time series due to differences in catchability over time and space (Conn 2010b). The hierarchical method separates out the components of sampling and process error for each index and models the overall trend for all indices, while remaining robust to differences in trends of spatial mixing proportions and differing gear selectivities across surveys (Conn 2010b). Due to the variability seen in the Atlantic smooth dogfish trends from standardized indices of abundance recommended by the SEDAR 39 Data Workshop and the resulting difficulties in fitting data to these multiple conflicting indices within the assessment model, it was recommended during a SEDAR 39 Assessment Webinar to look at the use of a hierarchical index to produce a single index that represents the most probable trend prior to stock assessment analysis. This document details the hierarchical analysis of the SEDAR 39 Data Workshop recommended indices of abundance for U.S Atlantic smooth dogfish and the Gulf of Mexico smoothhound species complex. In addition to running the hierarchical analysis for the 1981-2012 and 1972-2013 assessment model time frames determined during the Data Workshop, an analysis of only the state survey data for the 1981-2012 time frame was also conducted. This was done to look at the smaller scale surveys conducted in estuarine and nearshore waters that, as a whole, may better represent the timing and location of the smooth dogfish population in the U.S. Atlantic. This analysis excludes the Southeast Area Monitoring and Assessment Program (SEAMAP) South Atlantic bottom trawl survey, a survey conducted outside the main area of distribution for the species during the timing of the survey, and the Northeast Area Monitoring and Assessment Program (NEAMAP) and the Northeast Fisheries Science Center (NEFSC) autumn bottom trawl surveys. Although the NEAMAP and NEFSC autumn bottom trawl surveys were ranked high by the SEDAR 39 Indices Working Group due to their long time series (NEFSC) and/or their large area of coverage (NEAMAP and NEFSC), the NEFSC sampling is more offshore and timing for both the NEFSC and NEAMAP surveys may not always coincide with the timing of smooth dogfish in areas sampled. The hierarchical analysis for the Gulf of Mexico smoothhound indices was conducted to provide a measure of process error for these indices.

Data Analysis

Indices of abundance recommended by the SEDAR 39 Data Workshop for both the U.S. Atlantic smooth dogfish and the Gulf of Mexico smoothhound species complex were obtained from the SEDAR 39 Data Workshop Report to use for the hierarchical analysis. For each area (U.S. Atlantic and Gulf of Mexico) the recommended indices (standardized to their means) and coefficients of variation were used in a hierarchical analysis to estimate individual index process error, assuming a lognormal error structure, and a hierarchical index of abundance (Conn 2010b). The relative abundance indices and CVs for each analysis are provided in Tables 1 -3. The hierarchical analysis was conducted in a Bayesian framework using the same set of prior distributions as described by Conn (2010b) and used for other shark species for stock assessment purposes (Conn 2010a). All analyses were conducted using the R programming environment (R Development Core Team 2012).

Results

1981-2012 Atlantic smooth dogfish hierarchical index

For Atlantic smooth dogfish using data from 1981 to 2012, hierarchical analysis suggested that relative abundance decreased from the mid-1980s until the early 1990s, followed by an increasing trend into the early 2000s, and following a peak in 2002, a slight decreasing trend for the remainder of the time series (Figure 1). This model seemed to key in on the NEFSC autumn bottom trawl survey, which had the lowest sampling error CVs associated with their annual index values, with the exception of the peak in 2002 that comes from the majority of the state surveys. All surveys resulted in process error estimates of one or less with associated CVs no greater than 0.5. The model suggested that the Connecticut Department of Energy and Environmental Protection (CTDEEP) bottom trawl survey and the New Jersey Division of Fish and Wildlife (NJDFW) ocean trawl survey had the lowest levels of process error (these levels were consistent with process error CVs on the order of 0.4).

1981-2012 Atlantic smooth dogfish hierarchical index for state surveys only

For Atlantic smooth dogfish using only state survey data from 1981 to 2012, hierarchical analysis suggested that relative abundance had an increasing trend from the mid-1980s up to a large peak seen in 2002, followed by a decreasing trend, and then an uptick seen in recent years (Figure 3). This 2002 peak in abundance was seen in all state trawl surveys except the Delaware Division of Fish and Wildlife (DEDFW) bottom trawl survey. The model suggested that the CTDEEP bottom trawl survey, NJDFW ocean trawl survey, and the Rhode Island Division of

Fish and Wildlife (RIDFW) seasonal bottom trawl survey had the lowest levels of process error, with process error CVs ranging from 0.4 to 0.6 (Figure 4). Both the DEDFW bottom trawl survey and the Massachusetts Division of Marine Fisheries (MADMF) autumn bottom trawl survey had higher process error estimates (0.8), with CVs on the order of 0.2 (Figure 4).

1972-2012 Atlantic smooth dogfish hierarchical index

The hierarchical analysis using Atlantic smooth dogfish data from 1972 to 2012 showed similar results to the 1981-2012 analysis. The results suggested that relative abundance decreased from the mid-1970s until the early 1990s, followed by an increasing trend into the early 2000s, and following a peak in 2002, a slight decreasing trend for the remainder of the time series (Figure 5). This model also seemed to key in on the Northeast Fisheries Science Center (NEFSC) autumn bottom trawl survey, which had the lowest sampling error CVs associated with their annual index values, with the exception of the peak in 2002 that comes from the majority of the state surveys. All surveys resulted in process error estimates of one or less with associated CVs ranging from 0.2 to 0.9 (Figure 6).

Gulf of Mexico smoothhound complex hierarchical index

For the Gulf of Mexico smoothhound complex, hierarchical analysis suggested an overall increasing trend in relative abundance since the late-1980s (Figure 7). All surveys resulted in process error estimates of less than 0.3 with associated CVs ranging from 0.6 to 0.8 (Figure 8). The model suggested that the Gulf of Mexico SEAMAP summer groundfish trawl survey had the lowest level of process error and was also the longest running time series used in this hierarchical analysis.

Discussion

Hierarchical analysis was explored in an attempt to reconcile the conflicting trends seen in the Atlantic smooth dogfish indices of abundance recommended by the SEDAR 39 Data Workshop. The results of the Atlantic smooth dogfish hierarchical analyses indicate that, when present, the NEFSC autumn bottom trawl survey appears to drive the overall trend for the hierarchical analysis resulting in a decreasing trend in recent years. Although the NEFSC relative index of abundance was rated high by the Indices Working Group due to its spatial coverage and long time series, it may not best represent the Atlantic smooth dogfish abundance trend due to the survey timing and the deeper waters sampled. The hierarchical analysis results using only state survey data, which, although smaller in scale, in combination may better represent Atlantic smooth dogfish abundance, indicated an uptick in abundance in recent years.

Hierarchical analysis of the Gulf of Mexico smoothhound indices indicated an overall increasing trend in abundance and that there was not much process variation across surveys. These results provide supporting evidence that the standardization process used to develop the Gulf of Mexico survey indices did a good job of modeling the population trend by just modeling sampling error alone.

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Table 1. Relative abundance indices and CVs for smooth dogfish in the U.S. Atlantic for use in hierarchical analysis (1981-2012), including the index name and SEDAR document number.

	SEDAR39 DW-02		SEDAR39 DW-30		SEDAR39 DW-12		SEDAR39 DW-24		SEDAR39 DW-24		SEDAR39 DW-10		SEDAR39 DW-14		SEDAR39 DW-15	
YEAR	SEAMAP SA Trawl	CV	Fall NEAMAP Trawl	CV	CT DEEP Trawl	CV	Fall NEFSC Bottom Trawl	CV	Fall MA DMF Trawl	CV	RI DFW Trawl 1981-2012	CV	NJ DFW Trawl	CV	DE DFW Trawl 1981-2012	CV
1981							0.441	0.320	2.383	0.189	1.681	0.487			4.864	0.441
1982							0.629	0.447	3.035	0.317	1.256	0.463			12.036	0.455
1983							0.317	0.401	6.194	0.461	0.430	0.748			1.033	0.841
1984					7.527	0.333	0.939	0.261	8.234	0.372	1.449	0.391			3.175	0.570
1985					12.540	0.239	1.026	0.138	11.320	0.224	1.155	0.537				
1986					7.725	0.216	0.406	0.367	9.422	0.399	0.625	0.608				
1987					3.089	0.349	0.544	0.487	4.124	0.482	0.078	1.089				
1988					5.127	0.260	0.466	0.396	0.967	0.416			4.708	0.614		
1989					4.018	0.259	0.438	0.240	0.535	0.210	0.035	1.061	12.536	0.400		
1990					2.950	0.287	0.734	0.268	2.691	0.247	1.287	1.044	39.623	0.329	6.727	0.492
1991					3.699	0.278	0.219	0.309	3.369	0.258	0.159	0.756	18.823	0.340	4.620	0.433
1992					3.997	0.328	0.42	0.262	0.773	0.352	0.069	0.841	5.796	0.451	3.750	0.448
1993					4.312	0.308	0.329	0.176	0.769	0.206	0.545	0.564	7.001	0.428	10.679	0.341
1994	0.770	0.860			5.616	0.233	0.416	0.226	0.776	0.271	0.141	0.749	5.169	0.494	3.960	0.580
1995	1.224	0.790			3.310	0.278	0.572	0.257	1.943	0.479	0.213	1.043	39.900	0.319	3.406	0.424
1996	2.476	0.800			4.859	0.241	0.706	0.285	2.180	0.234	1.102	0.453	26.184	0.360	9.467	0.369
1997	0.467	0.940			2.123	0.349	0.498	0.268	2.012	0.206	0.332	1.047	15.680	0.360	19.620	0.303
1998	4.809	0.550			4.093	0.278	1.12	0.212	0.752	0.243	0.058	1.040	21.397	0.340	14.589	0.387
1999	12.449	0.500			7.365	0.209	2.052	0.228	0.876	0.239	0.333	0.528	38.408	0.398	18.939	0.311
2000	0.216	1.280			9.438	0.241	0.528	0.216	0.927	0.196	0.426	0.754	34.102	0.299	32.716	0.249
2001	5.460	0.670			9.414	0.259	1.808	0.403	0.622	0.252	0.764	0.618	36.709	0.340	28.021	0.261
2002	5.696	0.650			21.957	0.181	0.951	0.161	2.225	0.245	1.682	0.495	110.922	0.201	12.907	0.269
2003	13.356	0.530			10.770	0.325	2.085	0.242	1.524	0.215	1.526	0.369	54.808	0.360	25.172	0.305
2004	10.390	0.520			7.280	0.241	1.713	0.173	1.323	0.270	1.067	0.544	37.220	0.380	3.600	0.397
2005	17.263	0.510			5.883	0.307	1.125	0.202	4.170	0.234	0.727	0.645	52.956	0.360	2.129	0.437
2006	17.306	0.550			6.215	0.277	1.582	0.199	0.529	0.249	0.713	0.417	75.088	0.220	38.530	0.211
2007	2.431	0.690	12.140	0.612	9.590	0.242	1.266	0.260	1.377	0.216	0.875	0.519	61.482	0.299	37.001	0.207
2008	1.713	0.750	2.810	0.363	9.561	0.261	0.897	0.205	3.567	0.401	0.457	0.581	37.388	0.251	8.414	0.327
2009	1.395	0.740	7.100	0.217	11.347	0.225	1.262	0.233	1.768	0.370	0.756	0.608	32.989	0.380	10.505	0.284
2010	3.422	0.660	5.510	0.591	3.461	0.581	0.64	0.246	2.018	0.317	0.983	0.555	29.152	0.281	18.906	0.187
2011	1.901	0.680	4.170	0.330	11.663	0.233	0.794	0.179	0.797	0.243	0.703	0.488	63.803	0.238	17.652	0.262
2012	0.217	1.160	5.350	0.374	14.029	0.172	0.78	0.337	2.668	0.250	2.513	0.469	42.070	0.251	18.224	0.197

Table 2. Relative abundance indices and CVs for smooth dogfish in the U.S. Atlantic for use in hierarchical analysis (1981-2012), including the index name and SEDAR document number.

	SEDAR39 DW-02		SEDAR39 DW-30		SEDAR39 DW-12		SEDAR39 DW-24		SEDAR39 DW-24		SEDAR39 DW-10		SEDAR39 DW-14		SEDAR39 DW-15	
YEAR	SEAMAP SA Trawl	CV	Fall NEAMAP Trawl	CV	CT DEEP Trawl	CV	Fall NEFSC Bottom Trawl	CV	Fall MA DMF Trawl	CV	RI DFW Trawl 1980-2012	CV	NJ DFW Trawl	CV	DE DFW Trawl 1974-2012	CV
1972							0.467	0.277								
1973							1.216	0.179								
1974							0.773	0.211							3.0491	0.948
1975							1.939	0.233								
1976							2.004	0.324								
1977							1.709	0.245								
1978							0.798	0.314	4.784	0.292						
1979							1.385	0.359	6.680	0.353					0.8058	0.575
1980							0.561	0.155	5.814	0.294	1.573	0.470			1.4416	0.557
1981							0.441	0.320	2.383	0.189	1.769	0.475			5.6909	0.420
1982							0.629	0.447	3.035	0.317	1.264	0.577			13.2632	0.432
1983							0.317	0.401	6.194	0.461	0.280	1.100			1.3854	0.804
1984					7.527	0.333	0.939	0.261	8.234	0.372	1.759	0.380			3.7795	0.541
1985					12.540	0.239	1.026	0.138	11.320	0.224	1.272	0.549				
1986					7.725	0.216	0.406	0.367	9.422	0.399	0.472	0.642				
1987					3.089	0.349	0.544	0.487	4.124	0.482	0.070	1.132				
1988					5.127	0.260	0.466	0.396	0.967	0.416			4.708	0.614		
1989					4.018	0.259	0.438	0.240	0.535	0.210	0.040	1.100	12.536	0.400		
1990					2.950	0.287	0.734	0.268	2.691	0.247	1.319	1.100	39.623	0.329	7.8410	0.472
1991					3.699	0.278	0.219	0.309	3.369	0.258	0.121	0.796	18.823	0.340	5.4302	0.410
1992					3.997	0.328	0.42	0.262	0.773	0.352	0.051	0.882	5.796	0.451	4.4640	0.429
1993					4.312	0.308	0.329	0.176	0.769	0.206	0.508	0.651	7.001	0.428	12.0175	0.324
1994	0.770	0.860			5.616	0.233	0.416	0.226	0.776	0.271	0.100	0.795	5.169	0.494	4.6011	0.565
1995	1.224	0.790			3.310	0.278	0.572	0.257	1.943	0.479	0.220	1.100	39.900	0.319	4.0075	0.405
1996	2.476	0.800			4.859	0.241	0.706	0.285	2.180	0.234	0.889	0.471	26.184	0.360	10.7856	0.349
1997	0.467	0.940			2.123	0.349	0.498	0.268	2.012	0.206	0.325	1.101	15.680	0.360	21.5530	0.288
1998	4.809	0.550			4.093	0.278	1.12	0.212	0.752	0.243	0.060	1.100	21.397	0.340	16.7899	0.366
1999	12.449	0.500			7.365	0.209	2.052	0.228	0.876	0.239	0.347	0.545	38.408	0.398	20.9375	0.296
2000	0.216	1.280			9.438	0.241	0.528	0.216	0.927	0.196	0.325	0.801	34.102	0.299	35.1260	0.240
2001	5.460	0.670			9.414	0.259	1.808	0.403	0.622	0.252	0.862	0.643	36.709	0.340	30.2588	0.250
2002	5.696	0.650			21.957	0.181	0.951	0.161	2.225	0.245	1.268	0.542	110.922	0.201	13.8680	0.257
2003	13.356	0.530			10.770	0.325	2.085	0.242	1.524	0.215	1.800	0.413	54.808	0.360	26.8402	0.292
2004	10.390	0.520			7.280	0.241	1.713	0.173	1.323	0.270	1.463	0.487	37.220	0.380	4.1469	0.378
2005	17.263	0.510			5.883	0.307	1.125	0.202	4.170	0.234	0.903	0.794	52.956	0.360	2.5274	0.417
2006	17.306	0.550			6.215	0.277	1.582	0.199	0.529	0.249	0.893	0.472	75.088	0.220	40.5412	0.206
2007	2.431	0.690	12.140	0.612	9.590	0.242	1.266	0.260	1.377	0.216	1.352	0.540	61.482	0.299	38.7541	0.202
2008	1.713	0.750	2.810	0.363	9.561	0.261	0.897	0.205	3.567	0.401	0.674	0.641	37.388	0.251	9.3775	0.311
2009	1.395	0.740	7.100	0.217	11.347	0.225	1.262	0.233	1.768	0.370	1.653	0.542	32.989	0.380	11.4919	0.270
2010	3.422	0.660	5.510	0.591	3.461	0.581	0.64	0.246	2.018	0.317	1.286	0.540	29.152	0.281	19.6432	0.184
2011	1.901	0.680	4.170	0.330	11.663	0.233	0.794	0.179	0.797	0.243	0.859	0.470	63.803	0.238	18.9991	0.251
2012	0.217	1.160	5.350	0.374	14.029	0.172	0.78	0.337	2.668	0.250	3.668	0.468	42.070	0.251	19.0543	0.193

Table 3. Relative abundance indices and CVs for the smoothhound complex in the Gulf of Mexico for use in hierarchical analysis, including the index name and SEDAR document number.

	SEDAR39-DW-06		SEDAR39-DW-07		SEDAR39-DW-07		SEDAR39-DW-08	
YEAR	NMFS SE Bottom Longline	CV	NMFS SEAMAP Groundfish Trawl (Summer)	CV	NMFS SEAMAP Groundfish Trawl (Fall)	CV	NMFS Small Pelagics Trawl	CV
1982			0.044	0.759				
1983			0.000					
1984			0.034	0.634				
1985			0.025	0.756				
1986			0.030	0.636				
1987			0.029	0.564				
1988			0.003	1.042	0.085	0.515		
1989			0.026	0.636	0.138	0.402		
1990			0.040	0.452	0.144	0.440		
1991			0.026	0.515	0.044	0.564		
1992			0.097	0.344	0.072	0.636		
1993			0.052	0.401	0.073	0.474		
1994			0.111	0.349	0.162	0.386		
1995			0.064	0.377	0.318	0.320		
1996			0.053	0.376	0.081	0.448		
1997			0.053	0.378	0.111	0.386		
1998			0.047	0.482	0.116	0.475		
1999			0.038	0.433	0.099	0.428		
2000	0.425	0.359	0.112	0.316	0.220	0.374		
2001	0.251	0.238	0.077	0.453	0.109	0.428		
2002	0.399	0.196	0.060	0.401	0.088	0.406	0.184	0.321
2003	0.345	0.224	0.067	0.455	0.037	0.570	0.207	0.380
2004	0.320	0.248	0.053	0.415	0.114	0.401	0.195	0.330
2005			0.084	0.452	0.109	0.426		
2006	0.512	0.198	0.126	0.342	0.374	0.333	0.262	0.330
2007	0.373	0.221	0.075	0.359	0.139	0.485	0.278	0.243
2008	0.132	0.371	0.050	0.359	0.308	0.301	0.440	0.241
2009	0.662	0.215	0.150	0.302	0.280	0.302	0.424	0.409
2010	0.577	0.229	0.083	0.394	0.135	0.452	0.386	0.257
2011	0.510	0.218	0.174	0.335	0.129	0.476	0.293	0.275
2012	0.608	0.283	0.142	0.323	0.147	0.633	0.618	0.196

Table 4. Hierarchical indices and associated CVs. ATL81 = 1981-2012 Atlantic smooth dogfish, ATLSTATES = 1981-2012 Atlantic smooth dogfish using only state surveys, ATL72 = 1972-2012 Atlantic smooth dogfish, GOM = Gulf of Mexico smoothhound complex

YEAR	ATL81	CV	ATLSTATES	CV	ATL72	CV	GOM	CV
1972					0.5894	0.4270		
1973					1.3274	0.3749		
1974					0.8183	0.3671		
1975					2.0046	0.3944		
1976					2.0364	0.4380		
1977					1.7964	0.3997		
1978					1.0447	0.4146		
1979					1.1380	0.4078		
1980					0.7607	0.3317		
1981	0.9075	0.3722	1.4094	0.4462	0.7598	0.3674		
1982	1.1947	0.3677	1.5143	0.4306	1.0085	0.3871	0.8343	0.6287
1983	0.5490	0.4010	0.7690	0.5302	0.4797	0.4078	1.4636	1.3223
1984	1.2364	0.2905	1.3026	0.3334	1.1376	0.2870	0.6637	0.5873
1985	1.5881	0.2839	1.8129	0.3240	1.3930	0.2745	0.5643	0.6440
1986	0.9486	0.3032	1.1398	0.3336	0.8053	0.3071	0.5971	0.5818
1987	0.5428	0.3499	0.4785	0.3900	0.5080	0.3504	0.5631	0.5358
1988	0.5175	0.3064	0.5042	0.3432	0.4709	0.3070	0.3725	0.4858
1989	0.4386	0.2765	0.3954	0.3107	0.4150	0.2638	0.7364	0.4033
1990	0.7961	0.2788	0.7002	0.3265	0.7527	0.2708	0.7979	0.3720
1991	0.4600	0.2692	0.5214	0.2921	0.4113	0.2674	0.4220	0.4161
1992	0.3768	0.2810	0.3325	0.3230	0.3552	0.2764	1.1158	0.3633
1993	0.4665	0.2687	0.4993	0.3046	0.4059	0.2575	0.7035	0.3670
1994	0.4504	0.2731	0.4561	0.3214	0.4102	0.2657	1.4046	0.3362
1995	0.6493	0.2696	0.5983	0.3156	0.6194	0.2595	1.4196	0.3437
1996	0.8544	0.2570	0.8260	0.2865	0.7597	0.2522	0.7309	0.3555
1997	0.5174	0.2734	0.4820	0.3207	0.4753	0.2671	0.8102	0.3456
1998	0.7435	0.2781	0.5221	0.2966	0.7395	0.2747	0.8007	0.3867
1999	1.2519	0.2741	0.8775	0.2738	1.2591	0.2730	0.6628	0.3698
2000	0.9155	0.2594	1.0601	0.2811	0.7887	0.2587	1.4673	0.2890
2001	1.3083	0.2666	1.0960	0.2824	1.2343	0.2683	0.8431	0.2981
2002	2.1187	0.2600	2.4896	0.2570	1.8096	0.2728	0.8953	0.2665
2003	1.8598	0.2590	1.5530	0.2839	1.7599	0.2566	0.8166	0.2793
2004	1.2542	0.2670	0.9452	0.2802	1.2665	0.2582	0.8355	0.2639
2005	1.1465	0.2640	0.9462	0.3040	1.1292	0.2545	1.0211	0.3765
2006	1.5041	0.2595	1.1650	0.2986	1.4530	0.2493	1.5778	0.2552
2007	1.5365	0.2443	1.3735	0.2752	1.4493	0.2407	1.0667	0.2526
2008	0.9887	0.2361	1.0681	0.2760	0.9385	0.2313	1.0973	0.2893
2009	1.3180	0.2389	1.1906	0.2820	1.2792	0.2290	1.9149	0.2499
2010	0.9200	0.2577	0.9025	0.3131	0.8371	0.2494	1.3892	0.2570
2011	1.2175	0.2369	1.3585	0.2688	1.1048	0.2350	1.4695	0.2597
2012	1.4225	0.2421	1.7102	0.2616	1.2684	0.2428	1.9427	0.2553

Figure 1. Hierarchical index for the 1981-2012 Atlantic smooth dogfish relative abundance indices.

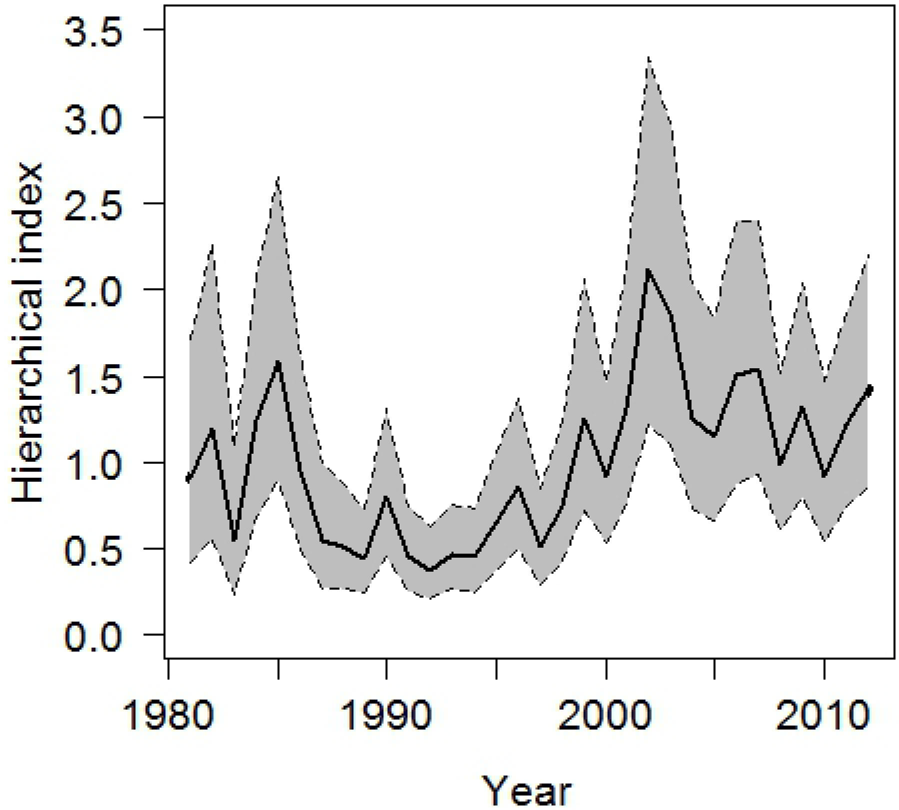

Figure 2. Process standard deviations for the indices used to develop the 1981-2012 Atlantic smooth dogfish heirarchical index

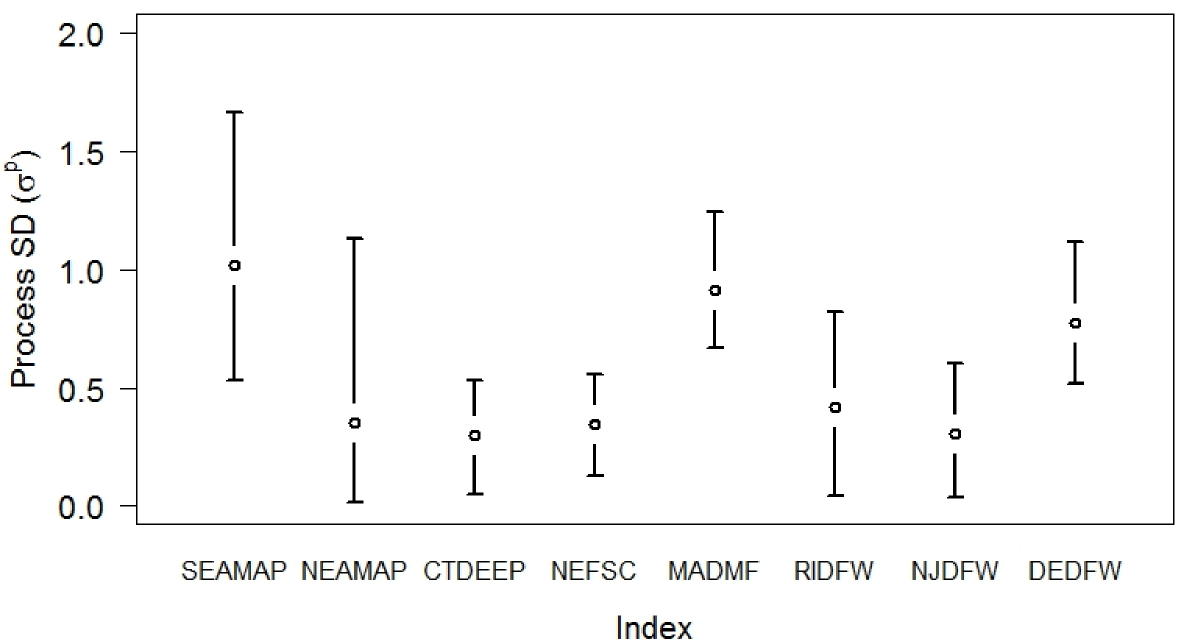

Figure 3. Hierarchical index for the 1981-2012 Atlantic smooth dogfish relative abundance indices for the state surveys only.

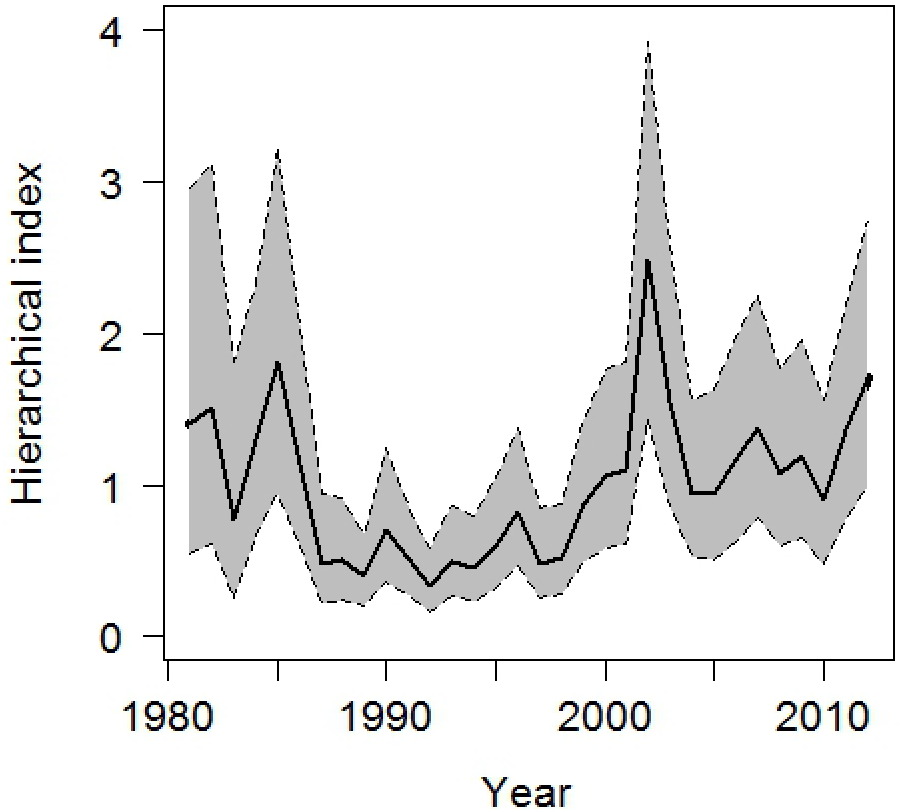

Figure 4. Process standard deviations for the indices used to develop the 1981-2012 Atlantic smooth dogfish heirarchical index for state surveys only

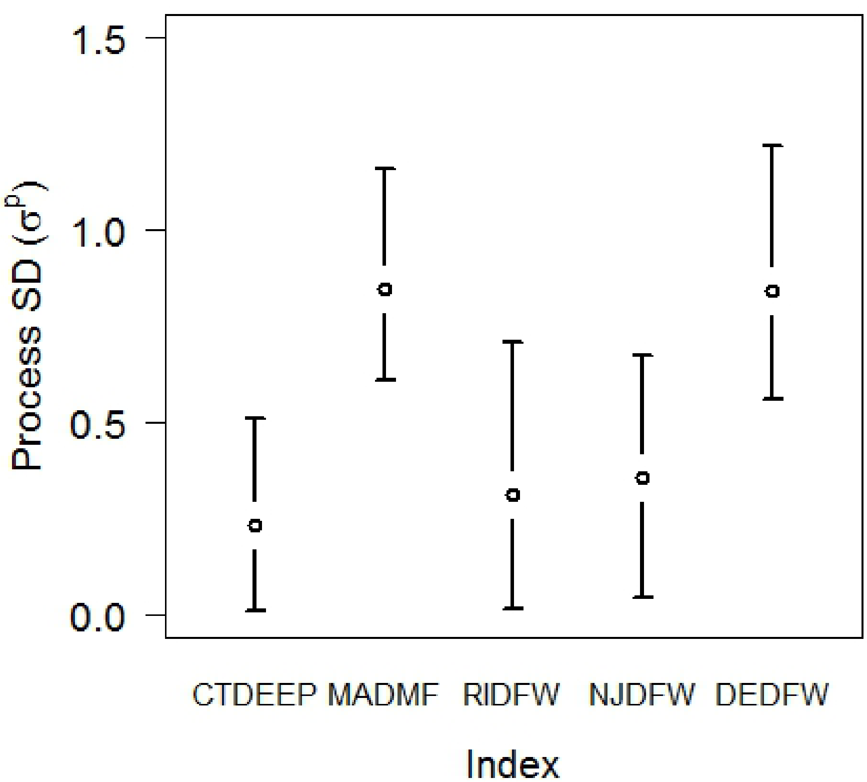

Figure 5. Hierarchical index for the 1972-2012 Atlantic smooth dogfish relative abundance indices.

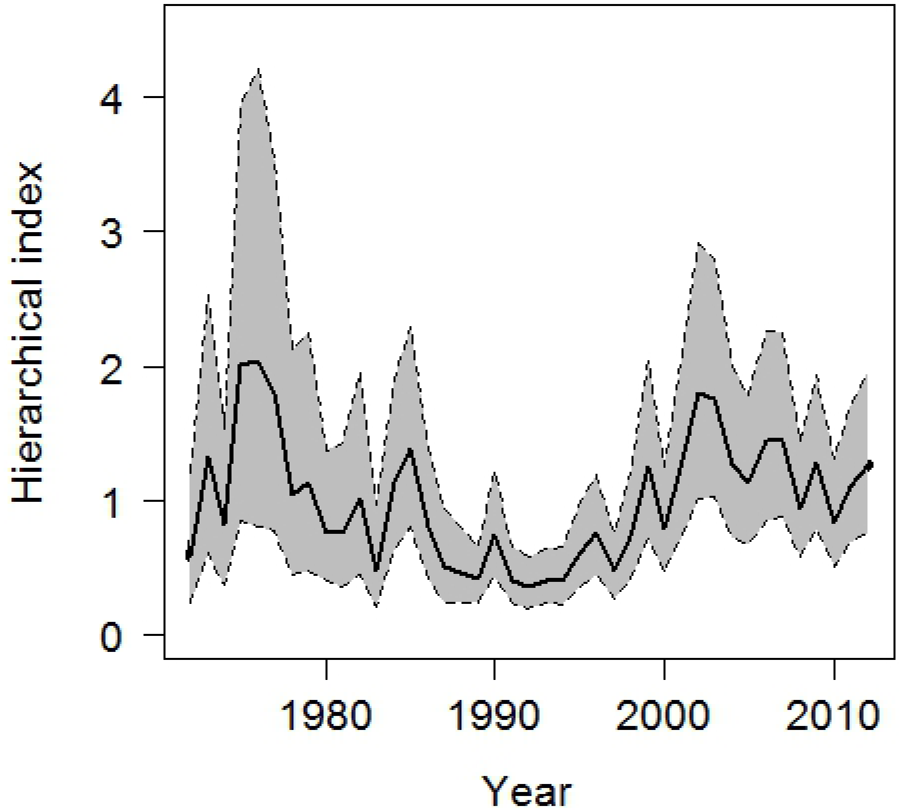

Figure 6. Process standard deviations for the indices used to develop the 1972-2012 Atlantic smooth dogfish heirarchical index

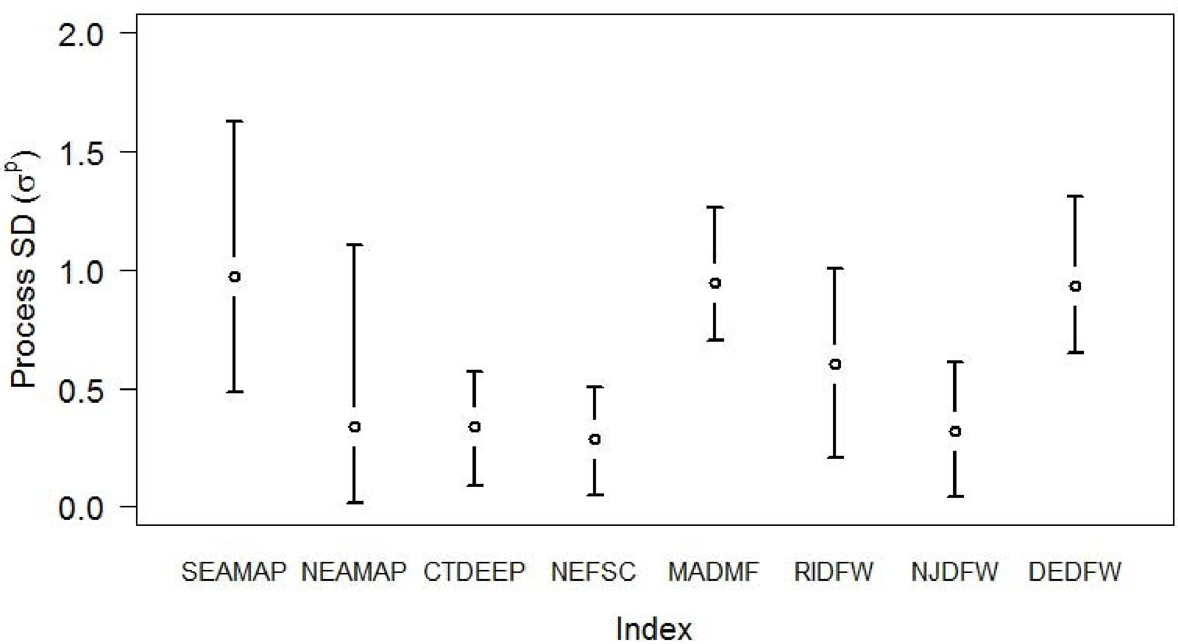

Figure 7. Hierarchical index for the Gulf of Mexico smoothhound complex relative abundance indices.

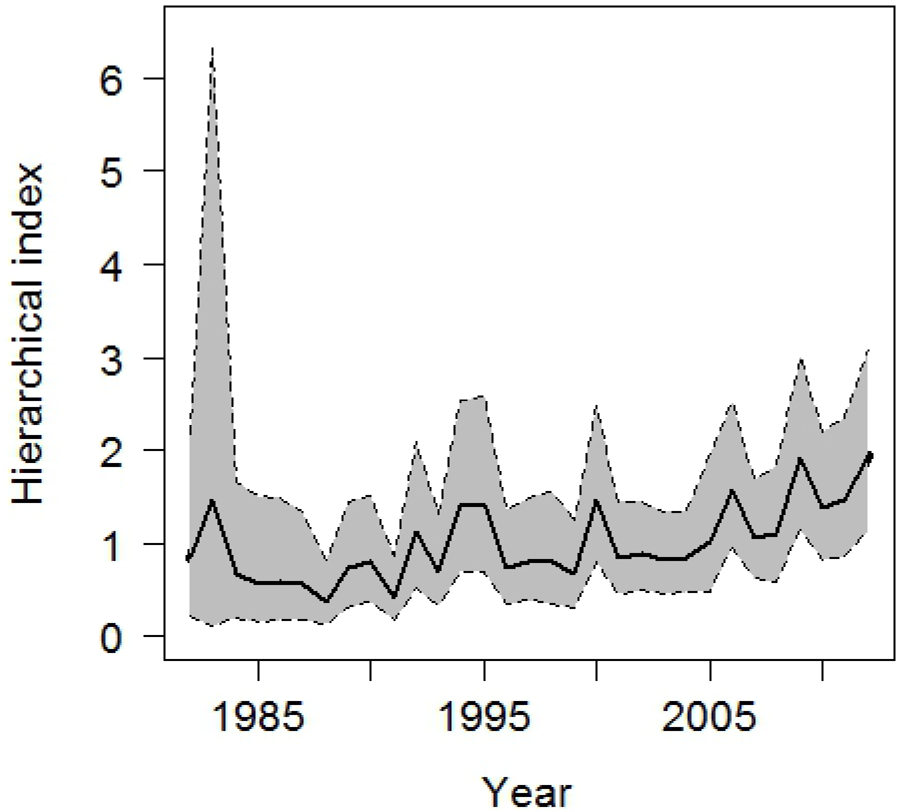

Figure 8. Process standard deviations for the indices used to develop the Gulf of Mexico smoothound complex heirarchical index.