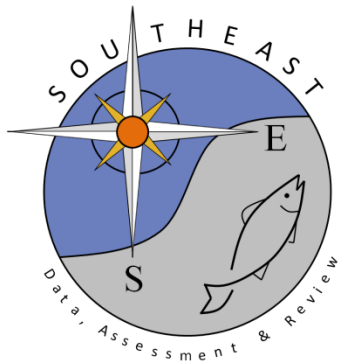# Improving discard time series for use in assessment sensitivity analyses

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Improving discard time series for use in assessment sensitivity analyses

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Summary

  This document details the use of a three-year moving average of discard estimates, a multi-year block averaging of discard estimates, and multi-year block averaging of discard ratios to produce discard estimates for improving available discard time series to use in sensitivity analyses in the SEDAR 65 assessment of Atlantic blacktip sharks. These methods were applied to the discard time series produced for the SEDAR 65 Data Workshop from the northeast sink gillnet fishery (SEDAR65-DW14), the southeast coastal gillnet fishery (SEDAR65-DW03), and the shark bottom longline fishery (SEDAR65-DW04). Trends for the moving average and multi-year block averaging methods were similar for each time series of live and dead discard estimates and helped to smooth the original trends. The multi-year block averaging of dead discard estimates produced significantly different results from the original method. The multi-year block averaging method uses known major management measures to inform the trend; and the use of discard ratios instead of original values also incorporates interannual variability in effort. The moving average method retains the consecutive zero estimates seen in the northeast sink gillnet fishery, which are likely not true zeros. Given this fishery is at the northern extent of the blacktip shark range, the blacktip catch and discards are expected to be lower, but not likely zero. The moving average method did result in a less variable trend for the shark bottom longline fishery back-calculated data at the beginning of the time series, but it also contained opposing peaks and valleys in estimates when compared to both the original and the block averaged data. For these reasons, we recommend the multi-year block averaging of discard ratios to produce discard estimates as the best method to improve the discard time series for use in sensitivity analyses.

Introduction

The discard estimates produced for the SEDAR 65 Data Workshop were not recommended for use in the assessment of Atlantic blacktip sharks. Three time series of discard estimates were reviewed from the following fisheries: the northeast sink gillnet fishery (NE GN fishery, SEDAR65-DW14), the southeast coastal gillnet fishery (SE GN fishery, SEDAR65-DW03), and the shark bottom longline fishery (BLL fishery, SEDAR65-DW04). These estimates were created using simple ratio-estimators that extrapolate observer catch-per-unit-effort data to the known effort of a fishery (total catch kept – NE GN, total sets – SE GN, total hooks – BLL). The resulting time series had highly variable trends that could not always be attributed to management measures and several zero estimates likely resulting from low observer coverage and/or patchy distribution in the area fished. This document details three methods to improve the time series of discard estimates for use in sensitivity analyses for the SEDAR 65 assessment of Atlantic blacktip sharks, a three-year moving average of discard estimates and two multi-year block averaging methods. Both multi-year block averaging methods use time blocks with respect to major management changes. One block method averages discard estimates and the other averages discard ratios, but using censored annual effort from logbook data (SE GN and BLL) or landings data from dealers (NE GN) to produce the discard estimates.

Data Analysis

The SEDAR 65 Data Workshop Panel recommended three methods for improving the discard time series: using a running average of bycatch estimates, multi-year block averaging of the bycatch estimates with respect to major management changes, and multi-year block averaging of the discard ratios, but using censored annual effort from logbook data or landings data from dealers to estimate discards. For this working paper, a three-year moving average was calculated for the original annual estimates of the SE GN (SEDAR65-DW03) and BLL (SEDAR65-DW04) fisheries and the estimates excluding all discards from observed trips that had large numbers of small (<40 cm fork length) blacktip sharks reported for the NE GN fishery (SEDAR65-DW14) to address the running average method. Original annual estimates for the SE GN and BLL fisheries included replacement values (calculated using the average ratios across all years) for years with low observer effort. The observer effort for the NE GN fishery was not considered low enough to warrant replacement values under the original method, so zero values were retained. The back-calculated discard ratio (average of annual discard ratios) reported and used in the NE GN data working paper excluded zero ratios. These zero ratios were retained in the analyses for this assessment working paper, as the values are expected to be low and correspond to the data used for estimation and the Data Workshop Panel recommended an average of all values for back calculation.

Multi-year block averaging of the original annual discard estimates and discard ratios using censored annual effort from logbook data (SE GN and BLL) or landings data from dealers (NE GN) were used to create annual discard estimates. In the second block averaging method that averages discard ratios, the interannual variability of discard estimates is driven by interannual variability in effort from the logbook data or in landing data from dealers. The multi-year blocks were based on the following management measures:

- 1998 –New England and Mid-Atlantic time/area closures to gillnets due to harbor porpoise interactions
- 2001 – Shark Finning Prohibition Act; LCS quota cut in half (set to 1997 levels that were not enacted until lawsuit was settled)
- 2003 – Move to regional quotas and trimester seasons, split LCS quota between ridgeback and non-ridgeback sharks, NC time/area closure
- 2006 – Feb-Mar no gillnetting off GA due to right whale interactions, sharks landed with 2nd dorsal and anal fins attached,
- 2008 – Shark Research Fishery implemented, sandbar sharks prohibited outside of research fishery, sharks landed with all fins attached

These measures resulted in the following blocks for the SE GN fishery: <2001, 2001-2002, 2003-2005, 2006-2007, and 2008-2018. Since the NE GN and BLL fisheries were not directly affected by some of the measures (i.e. closure to gillnets off GA), had more zero values, and/or less complete data (i.e. years with low observer coverage), there were fewer blocks for these fisheries: <1998, 1998-2000, 2001-2018 for NE GN and <2001, 2001-2007 , and 2008-2018 for BLL. A one-way repeated measures analysis of variance (ANOVA) and a Friedman Test for repeated measures were used to test for significant differences in means and medians, respectively between methods at α = 0.05.

Results

The annual live and dead discard estimates for the original, three-year moving average and multi-year block averaging methods are reported in Tables 1-3 and Figure 1. Trends for the three-year moving average and multi-year block averaging methods were similar for each time series of live and dead discard estimates and helped to smooth the original trends (Figure 1). The three methods used to smooth the original trends did not alter the central tendencies of the original data, with the exception of one measure of central tendency. There were no statistically significant differences between group means for the discard estimates produced by each method (original, three-year moving average, block averaged estimates, block averaged ratios) as determined by one-way repeated measures ANOVA (Tables 1-3). Friedman results indicated a statistically significant difference in group medians for the live and dead discard estimates of the NE GN fishery (Table 1). Post hoc tests using the Wilcoxon Signed Rank Test with Bonferroni correction (α= 0.05/4 = 0.0125) indicated that the only method with a statistically significant difference from the original method was the multi-year block averaging of the original live discard estimates (Z = -2.498, p = 0.01249). No statistically significant differences were found in post hoc tests between the original method and other methods for the dead discard estimates.

Discussion

The multi-year block averaging of the original dead discard estimates produced significantly different results from the original method, indicating that this method did not retain the central tendencies of the original method, at least for the dead discards. The multi-year block averaging method uses known major management measures to inform the trend; and the use of

discard ratios instead of original values also incorporates interannual variability in effort. The moving average method retains the consecutive zero estimates seen in the NE GN, which are likely not true zeros. Given this fishery is at the northern extent of the blacktip shark range, the zero values likely result from the patchy distribution of the blacktip shark in the areas fished, and effort within seasons and over time. Additionally, although the moving average method resulted in a less variable trend for the BLL back-calculated data at the beginning of the time series, it also contained opposing peaks and valleys in estimates when compared to both the original and the block averaged data. The only other time conflicting peaks and valleys in the time series were seen was when zero values were replaced. For these reasons, we recommend the multi-year block averaging of discard ratios to improve the time series of discard estimates for use in sensitivity analyses.

Table 1. Live and dead discard estimates for the northeast sink gillnet fishery using the original method reported in SEDAR65-DW14, a three-year moving average of discard estimates, multi-year block averaging of the discard estimates, and multi-year block averaging of the discard ratios to create discard estimates. The dashed lines separate out the multi-year blocks determined by management measures. The results from the one-way repeated measures analysis of variance (ANOVA, rep meas) and the Friedman Test for repeated measures are reported for both the live and dead discard estimates

year	total catch kept (all sp.)	annual live disc rate	live multi-year block rate ave	annual dead disc rate	dead multi-year block rate ave	S65-DW14* live disc	live 3-year moving ave	live multi-yr block est	live multi-yr block ratio	S65-DW14* dead disc	dead 3-year moving ave	dead multi-yr block est	dead multi-yr block ratio
1983	466121	0.0000032295	0.0000035728	0.0000031787	0.0000025429	2	1	27	2	1	1	9	1
1984	456466	0.0000032295	0.0000035728	0.0000031787	0.0000025429	1	2	27	2	1	2	9	1
1985	618686	0.0000032295	0.0000035728	0.0000031787	0.0000025429	2	2	27	2	2	2	9	2
1986	764905	0.0000032295	0.0000035728	0.0000031787	0.0000025429	2	3	27	3	2	3	9	2
1987	1241889	0.0000032295	0.0000035728	0.0000031787	0.0000025429	4	3	27	4	4	3	9	3
1988	586838	0.0000032295	0.0000035728	0.0000031787	0.0000025429	2	6	27	2	2	5	9	1
1989	3315777	0.0000032295	0.0000035728	0.0000031787	0.0000025429	11	7	27	12	11	7	9	8
1990	2531891	0.0000032295	0.0000035728	0.0000031787	0.0000025429	8	12	27	9	8	12	9	6
1991	5042011	0.0000032295	0.0000035728	0.0000031787	0.0000025429	16	16	27	18	16	16	9	13
1992	7261003	0.0000032295	0.0000035728	0.0000031787	0.0000025429	23	25	27	26	23	24	9	18
1993	10538967	0.0000032295	0.0000035728	0.0000031787	0.0000025429	34	32	27	38	33	31	9	27
1994	11562263	0.0000032295	0.0000035728	0.0000031787	0.0000025429	37	24	27	41	37	23	9	29
1995	12646263	0	0.0000035728	0	0.0000025429	0	12	27	45	0	12	9	32
1996	16000985	0	0.0000035728	0	0.0000025429	0	87	27	57	0	0	9	41
1997	17651176	0.0000148382	0.0000035728	0	0.0000025429	262	87	27	63	0	207	9	45
1998	23292104	0	0.0000190791	0.0000266002	0.0000232949	0	372	368	444	620	491	491	543
1999	19730449	0.0000432846	0.0000190791	0.0000432846	0.0000232949	854	368	368	376	854	491	491	460
2000	17832962	0.0000139527	0.0000190791	0	0.0000232949	249	368	368	340	0	285	491	415
2001	17889175	0	0.0000003018	0	0.0000003557	0	83	3	5	0	0	4	6
2002	16619962	0	0.0000003018	0	0.0000003557	0	0	3	5	0	0	4	6
2003	17146913	0	0.0000003018	0	0.0000003557	0	0	3	5	0	0	4	6
2004	14816503	0	0.0000003018	0	0.0000003557	0	0	3	4	0	0	4	5
2005	8649791	0	0.0000003018	0	0.0000003557	0	0	3	3	0	0	4	3
2006	8450416	0	0.0000003018	0	0.0000003557	0	0	3	3	0	0	4	3
2007	17335437	0	0.0000003018	0	0.0000003557	0	0	3	5	0	0	4	6
2008	15153409	0	0.0000003018	0	0.0000003557	0	0	3	5	0	0	4	5
2009	18254297	0	0.0000003018	0	0.0000003557	0	0	3	6	0	0	4	6
2010	10868149	0	0.0000003018	0	0.0000003557	0	0	3	3	0	0	4	4
2011	19822121	0	0.0000003018	0	0.0000003557	0	0	3	6	0	0	4	7
2012	15901945	0	0.0000003018	0	0.0000003557	0	0	3	5	0	0	4	6
2013	16205603	0	0.0000003018	0	0.0000003557	0	0	3	5	0	0	4	6
2014	22010975	0	0.0000003018	0	0.0000003557	0	12	3	7	0	0	4	8
2015	11505058	0.0000031279	0.0000003018	0	0.0000003557	36	16	3	3	0	2	4	4
2016	11694039	0.0000009972	0.0000003018	0.0000005197	0.0000003557	12	16	3	4	6	4	4	4
2017	10338475	0	0.0000003018	0.0000006569	0.0000003557	0	9	3	3	7	24	4	4
2018	11091106	0.0000013067	0.0000003018	0.0000052268	0.0000003557	14	7	3	3	58	32	4	4

*back calculation ratio in S65-DW14 excluded zero vaues

sum	1570	1568	1570	1565	1686	1677	1686	1742
median	1	6	15	5	0	2	7	6
mean	44	44	44	43	47	47	47	48

ANOVA, rep meas $F_{(3, 105)} = 0.0001, p = 0.99$ $F_{(3, 105)} = 0.0090, p = 0.99$

Friedman Test $X^2 (3, N=36) = 21.7083, p = .0001$ $X^2 (3, N=36) = 9.2083, p = 0.03$

Table 2. Live and dead discard estimates for the southeast coastal gillnet fishery using the original method reported in SEDAR65-DW03, a three-year moving average of discard estimates, multi-year block averaging of the discard estimates, and multi-year block averaging of the discard ratios to create discard estimates. The results from the one-way repeated measures analysis of variance (ANOVA, rep meas) and the Friedman Test for repeated measures are reported for both the live and dead discard estimates

year	total logbook sets	annual live disc rate	live multi-year block rate	annual dead disc rate	dead multi-year block rate	S65-DW03 live disc	live 3-year moving ave	live multi-yr block est	live multi-yr block ratio	S65-DW03 dead disc	dead 3-year moving ave	dead multi-yr block est	dead multi-yr block ratio
1998	2395	0	0.533	0	1.692	0	1482	988	1277	0	4623	3142	4052
1999	1855	1.598	0.533	4.984	1.692	2964	988	988	989	9245	3142	3142	3139
2000	1945	0	0.533	0.093	1.692	0	1564	988	1037	180	3641	3142	3291
2001	1872	0.923	1.612	0.800	2.855	1728	2013	3020	3018	1498	3627	5350	5345
2002	1874	2.301	1.612	4.910	2.855	4312	3058	3020	3021	9202	5236	5350	5350
2003	1558	2.011	1.150	3.215	4.932	3133	3106	1806	1792	5009	6841	8305	7684
2004	1547	1.210	1.150	4.080	4.932	1872	1806	1806	1779	6312	8305	8305	7630
2005	1812	0.228	1.150	7.502	4.932	414	1063	1806	2084	13593	7013	8305	8937
2006	2379	0.380	0.228	0.476	0.265	903	532	591	542	1134	4974	664	629
2007	3658	0.076	0.228	0.053	0.265	278	675	591	834	194	497	664	968
2008	3602	0.234	0.069	0.045	0.044	843	552	233	249	162	223	166	158
2009	4108	0.130	0.069	0.076	0.044	534	480	233	283	312	158	166	181
2010	2714	0.024	0.069	0	0.044	64	275	233	187	0	110	166	119
2011	3467	0.065	0.069	0.005	0.044	226	179	233	239	17	267	166	153
2012	3540	0.070	0.069	0.221	0.044	248	194	233	244	783	276	166	156
2013	1876	0.058	0.069	0.014	0.044	108	183	233	129	27	374	166	83
2014	3354	0.058	0.069	0.093	0.044	193	150	233	231	312	129	166	148
2015	3123	0.047	0.069	0.016	0.044	148	143	233	215	49	120	166	137
2016	2849	0.030	0.069	0	0.044	87	78	233	197	0	16	166	125
2017	2143	0	0.069	0	0.044	0	65	233	148	0	12	166	94
2018	2831	0.039	0.069	0.013	0.044	109	55	233	195	36	18	166	125
					sum	18164	18640	18164	18690	48065	49600	48195	48503
					median	248	532	233	283	194	374	166	181
					mean	865	888	865	890	2289	2362	2295	2310
					ANOVA, rep meas	$F_{(3, 60)} = 0.0196, p = 0.99$				$F_{(3, 60)} = 0.0119, p = 0.99$			
					Friedman Test	$X^2(3, N=21) = 1.9714, p = 0.58$				$X^2(3, N=21) = 6.0714, p = 0.11$			

Table 3. Live and dead discard estimates for the shark bottom longline fishery using the original method reported in SEDAR65-DW04, a three-year moving average of discard estimates, multi-year block averaging of the discard estimates, and multi-year block averaging of the discard ratios to create discard estimates. The results from the one-way repeated measures analysis of variance (ANOVA, rep meas) and the Friedman Test for repeated measures are reported for both the live and dead discard estimates

year	total hooks	annual live disc rate	live multi-year block rate ave	annual dead disc rate	dead multi-year block rate ave	S65-DW04 live disc	live 3-year moving ave	live multi-yr block est	live multi-yr block ratio	S65-DW04 dead disc	dead 3-year moving ave	dead multi-yr block est	dead multi-yr block ratio
1993	373270	0.00031	0.00031	0.00670	0.00670	116	177	154	116	2499	3819	3313	2499
1994	767570	0.00031	0.00031	0.00670	0.00670	239	149	154	239	5139	3201	3313	5139
1995	293603	0.00031	0.00031	0.00670	0.00670	91	199	154	91	1966	4274	3313	1966
1996	853758	0.00031	0.00031	0.00670	0.00670	266	160	154	266	5717	3439	3313	5716
1997	393413	0.00031	0.00031	0.00670	0.00670	122	177	154	122	2634	3807	3313	2634
1998	458687	0.00031	0.00031	0.00670	0.00670	143	132	154	143	3071	2840	3313	3071
1999	420234	0.00031	0.00031	0.00670	0.00670	131	132	154	131	2814	2850	3313	2814
2000	398160	0.00031	0.00031	0.00670	0.00670	124	130	154	124	2666	2792	3313	2666
2001	432662	0.00031	0.00022	0.00670	0.00480	135	147	109	96	2897	3158	2344	2076
2002	583965	0.00031	0.00022	0.00670	0.00480	182	166	109	130	3910	3579	2344	2803
2003	586888	0.00031	0.00022	0.00670	0.00480	183	169	109	131	3930	3631	2344	2817
2004	455745	0.00031	0.00022	0.00670	0.00480	142	148	109	102	3052	3190	2344	2187
2005	386396	0.00031	0.00022	0.00670	0.00480	120	87	109	86	2587	1885	2344	1854
2006	386212	0	0.00022	0.00004	0.00480	0	40	109	86	16	872	2344	1854
2007	207548	0	0.00022	0.00007	0.00480	0	12	109	46	14	262	2344	996
2008	112946	0.00031	0.00039	0.00670	0.00790	35	38	47	44	756	820	1095	893
2009	252278	0.00031	0.00039	0.00670	0.00790	78	60	47	97	1689	1283	1095	1994
2010	209491	0.00031	0.00039	0.00670	0.00790	65	54	47	81	1403	1427	1095	1656
2011	150252	0.00031	0.00039	0.00792	0.00790	19	28	47	58	1190	994	1095	1188
2012	88786	0	0.00039	0.00439	0.00790	0	6	47	34	390	875	1095	702
2013	126843	0	0.00039	0.00824	0.00790	0	10	47	49	1045	836	1095	1003
2014	173177	0.00018	0.00039	0.00620	0.00790	31	31	47	67	1074	1426	1095	1369
2015	155914	0.00040	0.00039	0.01385	0.00790	62	39	47	60	2159	1421	1095	1232
2016	92890	0.00027	0.00039	0.01110	0.00790	25	89	47	36	1031	1338	1095	734
2017	97453	0.00184	0.00039	0.00847	0.00790	179	75	47	38	825	778	1095	770
2018	71537	0.00031	0.00039	0.00670	0.00790	22	101	47	28	479	652	1095	565
sum						2510	2556	2510	2499	54953	55450	54953	53196
median						104	95	109	89	2063	1656	2344	1910
mean						97	98	97	96	2114	2133	2114	2046
ANOVA, rep meas						$F_{(3, 75)} = 0.0205, p = 0.99$				$F_{(3, 75)} = 0.0960, p = 0.96$			
Friedman Test						$X^2_{(3, N=26)} = 1.7192, p = 0.63$				$X^2_{(3, N=26)} = 3.2192, p = 0.36$			

Figure 1. Plot of annual estimates using original data from the SEDAR 65 Data Workshop (identified by document number), a three-year moving average of the discard estimates (3-yr mov), multi-year block averaging of the discard estimates (block est), and multi-year block averaging of the discard ratios to create discard estimates (block ratio) for the northeast sink gillnet fishery (NE GN) live (A) and dead (B) discards, the southeast coastal gillnet fishery (SE GN) live (C) and dead (D) discards, and the shark bottom longline fishery (BLL) live (E) and dead (F) discards.