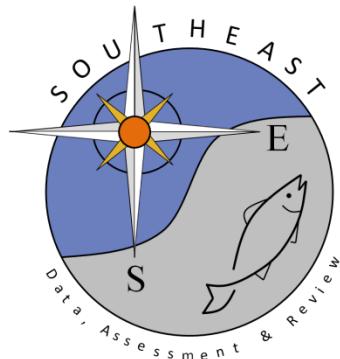


**Estimation of blacktip shark, *Carcharhinus limbatus*, discards in the northeast gillnet fishery
using data collected by the NOAA Northeast Fisheries Observer Program**

Camilla T. McCandless, Joseph J. Mello, and Katherine A. Sosebee

SEDAR65-DW14

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SEDAR 65 DATA WORKSHOP DOCUMENT
Estimation of blacktip shark, *Carcharhinus limbatus*, discards in the northeast gillnet fishery using
data collected by the NOAA Northeast Fisheries Observer Program

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Summary

Dead and live discards of blacktip sharks, *Carcharhinus limbatus*, from the Northeast Region's Mid-Atlantic sink-gillnet fishing fleet were estimated in numbers and weight using data collected by the Northeast Fisheries Observer Program from 1995 to 2018 and were back-calculated to 1984 for consideration during the SEDAR 65 assessment process.

Introduction

The Northeast Fisheries Science Center implemented an observer program in 1989 with the intent of developing estimates of discards for all species in the Northeast Region's fleets. Observers are deployed on commercial vessels in an effort to quantify bycatch and document protected species interactions. Within the gillnet fleet, vessels are selected based on the intended target species, mesh size used, and the likelihood of protected species interactions. Sampling priorities are determined by the funding source. This working paper focuses on the gillnet fleet. The majority of gillnet trips are single day trips with a gear configuration of anchored sink, drift sink, or drift floating gillnets and gillnet sets range from one to twenty per trip. Observers are tasked with collecting economic data, weather conditions, and gear characteristics, as well as, biological data for both the catch and bycatch. For shark bycatch, each fish is examined for status (alive, dead) when brought onboard, weight, length (fork length) sex, end status, and kept or discard status (and discard reason). Species specific shark identification was not consistent before 1995. This working paper develops ratio estimators from the Northeast Fisheries Observer Program data to apply to landings data for estimation of blacktip shark discards from the Northeast Region's Mid-Atlantic sink-gillnet fishing fleet from 1995 to 2018.

Methods

Discards were estimated using ratio-estimators based on the methodology described in Rago et al. (2005) updated in Wigley et al (2007). The estimators rely on a ratio of discards to total species kept. Only sink gillnet trips that occurred during the second through fourth quarters (April-June, July-September, October-December) and within coastal mid-Atlantic waters (Figure 1) were used to develop discard estimates for the Northeast Region's Mid-Atlantic sink-gillnet fishing fleet from 1995 to 2018. Mesh size was not used to split out sink gill net trips and all trips were included if they occurred within this stratification regardless of whether or not they caught blacktip sharks. If fish status was unknown at haulback and unknown when discarded then the fish was considered a dead discard. If the fish status was alive at haulback and unknown when discarded then the fish was considered a live discard. For calculating total catch, all weights were converted to round live weight using the Commercial Fisheries Database System conversion factors. For purposes of SEDAR 65, blacktip sharks under 40 cm fork length were excluded from this analysis, as these lengths are smaller than the size at birth. Blacktip shark discard weights, for those sharks without measured weights, were calculated from reported lengths using the length-length and length-weight formulas from Pollack et al. (2019).

The discard ratio (R_h) for blacktip sharks in stratum h (annual quarter) is the sum of discard number or weight (d_{ih}) for all observed trips (i) divided by the sum of total species kept weights (k_{ih}) for all observed trips:

$$R_h = \frac{\sum_{i=1}^{n_h} d_{ih}}{\sum_{i=1}^{n_h} k_{ih}}$$

The stratum discard estimate (D_h) is simply the product of the discard ratio R_h and the total species kept weight for the fishery (K_h) within that annual quarter, $D_h=R_h K_h$. Annual discard estimates (\hat{D}) are the sum across strata. The variance (V) for each annual discard estimate is defined as:

$$V = \sum_{h=1}^L K_h^2 \left(\frac{N_h - n_h}{n_h N_h} \right) \frac{1}{\left(\frac{\sum_{i=1}^{n_h} k_{ih}}{n_h} \right)^2} \left[\frac{\sum_{i=1}^{n_h} (d_{ih}^2 + R_h^2 k_{ih}^2 - 2R_h d_{ih} k_{ih})}{n_h - 1} \right]$$

Where N_h and n_h are the number of total trips and observed trips within stratum h , respectively.

The coefficient of variation (CV) for each annual discard estimate (\hat{D}) is defined as:

$$CV = \frac{\sqrt{V}}{\hat{D}}$$

To back-calculate the discards to 1984 (the start year for the SEDAR 65 catch time series), the average discard ratios across all years for live and dead discards by number and weight were applied to the annual total landings for the Mid-Atlantic statistical areas identified in Figure 1 from the dealer database. Not all Mid-Atlantic states reported until 1989; therefore, the estimates before this time are likely underestimated.

Following discussion of the results, estimates were created excluding all discards from trips that had large numbers of small (<40 cm fork length) blacktip sharks reported. The sharks under 40 cm fork length were already excluded from the initial analyses, but since there was evidence of misidentification on these observed trips, the remaining blacktip sharks reported may likely have been misidentified as well.

Results

Estimated live and dead discards from 1995–2018 for the Northeast’s sink gillnet fishery in the Mid-Atlantic from North Carolina to New York within the statistical areas identified in Figure 1 are summarized in Table 1. Back-calculated estimates to 1984 for the same region are reported in Table 2. Detailed strata results are given in Appendix 1 (Tables 1 and 2).

Estimated discards from the analyses excluding all discards from observed trips that had large numbers of small (<40 cm fork length) blacktip sharks reported are summarized in Table 3 and back-calculated estimates to 1984 are reported in Table 4. Detailed strata results are given in Appendix 1 (Tables 3 and 4).

References

Pollack, AG, WB Driggers III, DS Hanisko, and G.W. Ingram, Jr. 2019. Distribution and Length Data for Blacktip Sharks Captured on the NOAA/NMFS/SEFSC/MSLABS Bottom Longline Survey in the Western North Atlantic Ocean. SEDAR65-DW15. SEDAR, North Charleston, SC. 16pp.

Rago, PJ, SE Wigley, and MJ Fogarty. 2005. NEFSC Bycatch Estimation Methodology: Allocation, Precision, and Accuracy. NOAA/NMFS/NEFSC. NEFSC Reference Document 05-09.

Wigley, SE, PJ Rago, KA Sosebee, and DL Palka. 2007. The Analytic Component to the Standardized Bycatch Reporting Methodology Omnibus Amendment: Sampling Design, and Estimation of Precision and Accuracy (*Second Edition*). NOAA/NMFS/NEFSC. NEFSC Reference Document 07-09.

Table 1. Annual live and dead discard estimates with the corresponding variance and CV.

year	total OBS est number				est weight (lbs)				est number				est weight (lbs)				
	trips	trips	live disc	variance	CV	live disc	variance	CV	dead disc	variance	CV	dead disc	variance	CV	dead disc	variance	CV
1995	8215	225	0			0			0			0			0		
1996	9105	189	0			0			0			0			0		
1997	13011	159	262	34897.52	0.7133	4382.6	11859086.05	0.7858	0			0			0		
1998	23528	85	12949	178154366.65	1.0308	18834.6	376921635.22	1.0308	2974	6276189.21	0.8424	3482.0	7170599.31	0.7691			
1999	26172	60	854	755723.53	1.0179	5978.2	37030452.82	1.0179	854	370075.16	0.7123	2562.1	3750403.17	0.7559			
2000	25337	66	1615	1538882.10	0.7681	9442.7	47894067.43	0.7329	0			0			0		
2001	19115	52	2068	4871363.65	1.0675	2067.5	4871363.65	1.0675	0			0			0		
2002	24443	36	0			0			0			0			0		
2003	22369	30	191	37984.66	1.0179	191.5	37984.66	1.0179	0			0			0		
2004	13047	42	0			0			0			0			0		
2005	13410	75	0			0			0			0			0		
2006	11262	14	0			0			0			0			0		
2007	15037	28	0			0			0			0			0		
2008	11261	32	0			0			0			0			0		
2009	15108	32	0			0			0			0			0		
2010	12413	108	0			0			0			0			0		
2011	16992	46	0			0			0			0			0		
2012	12543	61	0			0			0			0			0		
2013	13448	28	0			0			0			0			0		
2014	14772	112	0			0			0			0			0		
2015	13088	236	36	1286.04	0.9965	72.0	5144.16	0.9965	0			0			0		
2016	11574	327	12	133.10	0.9893	466.5	212974.90	0.9893	6	33.71	0.9554	31.6	911.40	0.9554			
2017	9125	373	0			0			7	39.87	0.9297	27.2	637.87	0.9297			
2018	10127	312	14	204.34	0.9863	55.1	2950.64	0.9863	58	1670.24	0.7050	3997.1	11585226.39	0.8515			

Table 2. Back-calculated live and dead discard estimates based on average discard rates (1995-2018) and total annual landings.

year	total		ave num	est num		ave weight	est weight (lbs)		ave num	est num		ave weight	est weight (lbs)	
	landings (lbs)	live d/k		live disc	live d/k		live disc	live disc		dead d/k	dead disc		dead d/k	dead disc
1984	*456466	0.0000601	27	0.0001334		60.91	0.0000139	6	0.0001109		50.62			
1985	*618686	0.0000601	37	0.0001334		82.56	0.0000139	9	0.0001109		68.61			
1986	*764905	0.0000601	46	0.0001334		102.07	0.0000139	11	0.0001109		84.82			
1987	*1241889	0.0000601	75	0.0001334		165.72	0.0000139	17	0.0001109		137.72			
1988	*586838	0.0000601	35	0.0001334		78.31	0.0000139	8	0.0001109		65.08			
1989	3315777	0.0000601	199	0.0001334		442.45	0.0000139	46	0.0001109		367.69			
1990	2531891	0.0000601	152	0.0001334		337.85	0.0000139	35	0.0001109		280.77			
1991	5042011	0.0000601	303	0.0001334		672.80	0.0000139	70	0.0001109		559.12			
1992	7261003	0.0000601	437	0.0001334		968.90	0.0000139	101	0.0001109		805.19			
1993	10538967	0.0000601	634	0.0001334		1406.31	0.0000139	146	0.0001109		1168.69			
1994	11562263	0.0000601	695	0.0001334		1542.86	0.0000139	160	0.0001109		1282.16			

*Not all Mid-Atlantic states reported landings until 1989

Table 3. Annual live and dead discard estimates with the corresponding variance and CV for the analyses excluding all discards from observed trips that had large numbers of small (<40 cm fork length) blacktip sharks reported.

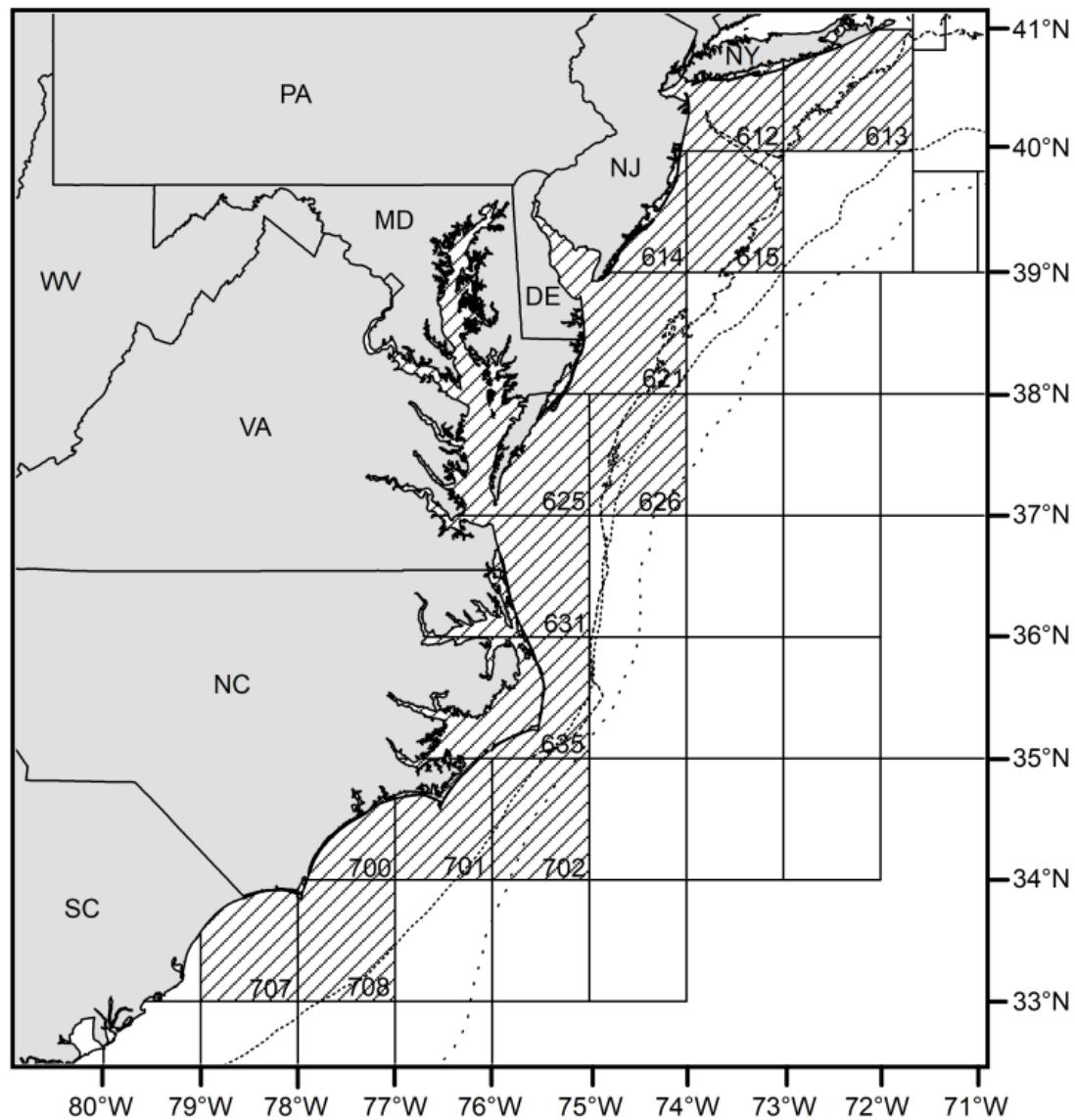
year	total OBS est number				est weight (lbs)				est number				est weight (lbs)				
	trips	trips	live disc	variance	CV	live disc	variance	CV	dead disc	variance	CV	dead disc	variance	CV	dead disc	variance	CV
1995	8215	225	0			0			0			0			0		
1996	9105	189	0			0			0			0			0		
1997	13011	159	262	34897.52	0.7133	4382.6	11859086.05	0.7858	0			0			0		
1998	23528	85	0			0			619.57425	386771.26	1.0038	1127.6	1281198.76	1.0038			
1999	26172	60	854	755723.53	1.0179	5978.2	37030452.82	1.0179	854.02522	370075.16	0.7123	2562.1	3750403.17	0.7559			
2000	25337	66	249	68661.62	1.0531	3234.6	11603813.86	1.0531	0			0					
2001	19115	52	0			0			0			0			0		
2002	24443	36	0			0			0			0			0		
2003	22369	30	0			0			0			0			0		
2004	13047	42	0			0			0			0			0		
2005	13410	75	0			0			0			0			0		
2006	11262	14	0			0			0			0			0		
2007	15037	28	0			0			0			0			0		
2008	11261	32	0			0			0			0			0		
2009	15108	32	0			0			0			0			0		
2010	12413	108	0			0			0			0			0		
2011	16992	46	0			0			0			0			0		
2012	12543	61	0			0			0			0			0		
2013	13448	28	0			0			0			0			0		
2014	14772	112	0			0			0			0			0		
2015	13088	236	36	1286.04	0.9965	72.0	5144.16	0.9965	0			0			0		
2016	11574	327	12	133.10	0.9893	466.5	212974.90	0.9893	6.0769445	33.71	0.9554	31.6	911.40	0.9554			
2017	9125	373	0			0			6.7915533	39.87	0.9297	27.2	637.87	0.9297			
2018	10127	312	14	204.34	0.9863	55.1	2950.64	0.9863	57.970634	1670.24	0.7050	3997.1	11585226.39	0.8515			

Table 4. Back-calculated live and dead discard estimates based on average discard rates (1995-2018) and total annual landings for the analyses excluding all discards from observed trips that had large numbers of small (<40 cm fork length) blacktip sharks reported.

year	total		ave num	est num	ave weight	est weight (lbs)	ave num	est num	ave weight	est weight (lbs)
	landings (lbs)	live d/k					live disc	dead d/k	dead disc	dead d/k
1984	*456466	0.0000053	2	0.0000482	22.00	0.0000059	3	0.0001029	46.95	
1985	*618686	0.0000053	3	0.0000482	29.81	0.0000059	4	0.0001029	63.64	
1986	*764905	0.0000053	4	0.0000482	36.86	0.0000059	4	0.0001029	78.68	
1987	*1241889	0.0000053	7	0.0000482	59.84	0.0000059	7	0.0001029	127.74	
1988	*586838	0.0000053	3	0.0000482	28.28	0.0000059	3	0.0001029	60.36	
1989	3315777	0.0000053	17	0.0000482	159.78	0.0000059	19	0.0001029	341.07	
1990	2531891	0.0000053	13	0.0000482	122.00	0.0000059	15	0.0001029	260.43	
1991	5042011	0.0000053	27	0.0000482	242.96	0.0000059	30	0.0001029	518.63	
1992	7261003	0.0000053	38	0.0000482	349.89	0.0000059	42	0.0001029	746.88	
1993	10538967	0.0000053	55	0.0000482	507.84	0.0000059	62	0.0001029	1084.06	
1994	11562263	0.0000053	61	0.0000482	557.15	0.0000059	68	0.0001029	1189.31	

*Not all Mid-Atlantic states reported landings until 1989

Figure 1. Statistical Areas (shaded) used for estimation of blacktip discards from the Northeast Region's Mid-Atlantic sink-gillnet fishery.



Appendix 1. Table 1. Live discard ratios and estimated quarterly discards.

year	qtr	total trips	OBS trips	OBS total catch kept	numbers live disc	weight live disc	numbers live d/k	weight live d/k	total catch kept	est number live disc	variance	est weight live disc	variance
1995	2	3850	77	187452	0	0	0	0	5396578	0		0	
1995	3	1262	49	76520	0	0	0	0	3161014	0		0	
1995	4	3103	99	235888	0	0	0	0	4088671	0		0	
1996	2	4245	71	195625	0	0	0	0	8189278	0		0	
1996	3	1403	47	62888	0	0	0	0	5708407	0		0	
1996	4	3457	71	187467	0	0	0	0	2103300	0		0	
1997	2	5083	69	229396	0	0	0	0	6188031	0		0	
1997	3	3280	32	53592	3	50.2	0.0000560	0.0009367	4678742	262	34897.52	4382.6	11859086.05
1997	4	4648	58	160402	0	0	0	0	6784403	0		0	
1998	2	8476	37	103860	0	0	0	0	9581733	0		0	
1998	3	5897	8	3558	11	16	0.0030916	0.0044969	4188345	12949	178154366.65	18834.6	376921635.22
1998	4	9155	40	76843	0	0	0	0	9522026	0		0	
1999	2	10802	21	24139	0	0	0	0	9358133	0		0	
1999	3	6114	13	8628	2	14	0.0002318	0.0016227	3684094	854	755723.53	5978.2	37030452.82
1999	4	9256	26	23416	0	0	0	0	6688222	0		0	
2000	2	11609	20	18055	3	16	0.0001662	0.0008862	6724732	1117	1407623.20	5959.3	36258634.08
2000	3	7831	10	20817	2	14	0.0000961	0.0006725	5179659	498	131258.90	3483.4	11635433.35
2000	4	5897	36	55917	0	0	0	0	5928571	0		0	
2001	2	6956	26	44253	0	0	0	0	6332842	0		0	
2001	3	5068	6	4035	2	2	0.0004957	0.0004957	4170681	2068	4871363.65	2067.5	4871363.65
2001	4	7091	20	24355	0	0	0	0	7385652	0		0	
2002	2	7219	13	17231	0	0	0	0	6573098	0		0	
2002	3	7511	6	3374	0	0	0	0	4232936	0		0	
2002	4	9713	17	23175	0	0	0	0	5813928	0		0	
2003	2	9155	17	24521	1	1	0.0000408	0.0000408	4694900	191	37984.66	191.5	37984.66
2003	3	4922	8	8670	0	0	0	0	8833809	0		0	
2003	4	8292	5	20187	0	0	0	0	3618204	0		0	
2004	2	4831	1	3067	0	0	0	0	6489018	0		0	
2004	3	3163	1	18	0	0	0	0	3779103	0		0	
2004	4	5053	40	54271	0	0	0	0	4548382	0		0	
2005	2	5218	57	139214	0	0	0	0	4049135	0		0	
2005	3	3664	2	6036	0	0	0	0	1799729	0		0	
2005	4	4528	16	42410	0	0	0	0	2800927	0		0	
2006	2	4273	8	17939	0	0	0	0	3883817	0		0	
2006	3	2786	1	1952	0	0	0	0	1802977	0		0	
2006	4	4203	5	10378	0	0	0	0	2763622	0		0	
2007	2	4695	12	31824	0	0	0	0	6741640	0		0	
2007	3	3805							3972633	0		0	
2007	4	6537	16	25623	0	0	0	0	6621164	0		0	
2008	2	4610	10	29273	0	0	0	0	6734243	0		0	
2008	3	2340	5	9394	0	0	0	0	3306429	0		0	
2008	4	4311	17	34898	0	0	0	0	5112737	0		0	
2009	2	5423	17	36837	0	0	0	0	7771602	0		0	
2009	3	4412							4373842	0		0	
2009	4	5273	15	31220	0	0	0	0	6108853	0		0	
2010	2	4575	47	169453	0	0	0	0	5549074	0		0	
2010	3	3277	2	1220					2021831	0		0	
2010	4	4561	59	152352	0	0	0	0	3297244	0		0	
2011	2	5821	25	67410	0	0	0	0	7240723	0		0	
2011	3	4108	2	0	0	0	0	0	4220932	0		0	
2011	4	7063	19	71529	0	0	0	0	8360466	0		0	
2012	2	3238	55	284376	0	0	0	0	7450971	0		0	
2012	3	3382	1	457	0	0	0	0	2768607	0		0	
2012	4	5923	5	21322	0	0	0	0	5682367	0		0	
2013	2	5096	16	60923	0	0	0	0	7713556	0		0	
2013	3	3026	1	7690	0	0	0	0	2727707	0		0	
2013	4	5326	11	29517	0	0	0	0	5764340	0		0	
2014	2	6021	34	123712	0	0	0	0	10373892	0		0	
2014	3	3051	14	17916	0	0	0	0	4186981	0		0	
2014	4	5700	64	225088	0	0	0	0	7450102	0		0	
2015	2	4967	85	272510	2	4	0.0000073	0.0000147	4903331	36	1286.04	72.0	5144.16
2015	3	2865	43	97006	0	0	0	0	1432352	0		0	
2015	4	5256	108	371674	0	0	0	0	5169374	0		0	
2016	2	4863	138	457929	0	0	0	0	5840419	0		0	
2016	3	1756	56	90018	0	0	0	0	547035	0		0	
2016	4	4955	133	455042	1	40	0.0000022	0.00000879	5306585	12	133.10	466.5	212974.90
2017	2	4057	146	557682	0	0	0	0	5288137	0		0	
2017	3	1097	110	96189	0	0	0	0	653270	0		0	
2017	4	3971	117	374109	0	0	0	0	4397068	0		0	
2018	2	4540	118	366457	0	0	0	0	5575831	0		0	
2018	3	1635	51	43868	1	3.8	0.0000228	0.0000866	635758	14	204.34	55.1	2950.64
2018	4	3952	143	490426	0	0	0	0	4879517	0		0	
				AVE	0.0000601	0.0001334							

Appendix 1. Table 2. Dead discard ratios and estimated quarterly discards.

year	qtr	total		OBS	OBS total	numbers	weight	numbers	weight	total	est number	est weight		
		trips	trips	catch kept	dead disc	dead disc	dead d/k	dead d/k	dead d/k	catch kept	dead disc	variance	dead disc	variance
1995	2	3850	77	187452	0	0	0	0	0	5396578	0		0	
1995	3	1262	49	76520	0	0	0	0	0	3161014	0		0	
1995	4	3103	99	235888	0	0	0	0	0	4088671	0		0	
1996	2	4245	71	195625	0	0	0	0	0	8189278	0		0	
1996	3	1403	47	62888	0	0	0	0	0	5708407	0		0	
1996	4	3457	71	187467	0	0	0	0	0	2103300	0		0	
1997	2	5083	69	229396	0	0	0	0	0	6188031	0		0	
1997	3	3280	32	53592	0	0	0	0	0	4678742	0		0	
1997	4	4648	58	160402	0	0	0	0	0	6784403	0		0	
1998	2	8476	37	103860	0	0	0	0	0	9581733	0		0	
1998	3	5897	8	3558	2	2	0.0005621	0.0005621	4188345	2354	5889400.55	2354.3	5889400.55	
1998	4	9155	40	76843	5	9.1	0.0000651	0.0001184	9522026	620	386788.66	1127.6	1281198.76	
1999	2	10802	21	24139	0	0	0	0	9358133	0		0		
1999	3	6114	13	8628	2	6	0.0002318	0.0006954	3684094	854	370075.16	2562.1	3750403.17	
1999	4	9256	26	23416	0	0	0	0	6688222	0		0		
2000	2	11609	20	18055	0	0	0	0	6724732	0		0		
2000	3	7831	10	20817	0	0	0	0	5179659	0		0		
2000	4	5897	36	55917	0	0	0	0	5928571	0		0		
2001	2	6956	26	44253	0	0	0	0	6332842	0		0		
2001	3	5068	6	4035	0	0	0	0	4170681	0		0		
2001	4	7091	20	24355	0	0	0	0	7385652	0		0		
2002	2	7219	13	17231	0	0	0	0	6573098	0		0		
2002	3	7511	6	3374	0	0	0	0	4232936	0		0		
2002	4	9713	17	23175	0	0	0	0	5813928	0		0		
2003	2	9155	17	24521	0	0	0	0	4694900	0		0		
2003	3	4922	8	8670	0	0	0	0	8833809	0		0		
2003	4	8292	5	20187	0	0	0	0	3618204	0		0		
2004	2	4831	1	3067	0	0	0	0	6489018	0		0		
2004	3	3163	1	18	0	0	0	0	3779103	0		0		
2004	4	5053	40	54271	0	0	0	0	4548382	0		0		
2005	2	5218	57	139214	0	0	0	0	4049135	0		0		
2005	3	3664	2	6036	0	0	0	0	1799729	0		0		
2005	4	4528	16	42410	0	0	0	0	2800927	0		0		
2006	2	4273	8	17939	0	0	0	0	3883817	0		0		
2006	3	2786	1	1952	0	0	0	0	1802977	0		0		
2006	4	4203	5	10378	0	0	0	0	2763622	0		0		
2007	2	4695	12	31824	0	0	0	0	6741640	0		0		
2007	3	3805							3972633	0		0		
2007	4	6537	16	25623	0	0	0	0	6621164	0		0		
2008	2	4610	10	29273	0	0	0	0	6734243	0		0		
2008	3	2340	5	9394	0	0	0	0	3306429	0		0		
2008	4	4311	17	34898	0	0	0	0	5112737	0		0		
2009	2	5423	17	36837	0	0	0	0	7771602	0		0		
2009	3	4412							4373842	0		0		
2009	4	5273	15	31220	0	0	0	0	6108853	0		0		
2010	2	4575	47	169453	0	0	0	0	5549074	0		0		
2010	3	3277	2	1220					2021831	0		0		
2010	4	4561	59	152352	0	0	0	0	3297244	0		0		
2011	2	5821	25	67410	0	0	0	0	7240723	0		0		
2011	3	4108	2	0	0	0	0	0	4220932	0		0		
2011	4	7063	19	71529	0	0	0	0	8360466	0		0		
2012	2	3238	55	284376	0	0	0	0	7450971	0		0		
2012	3	3382	1	457	0	0	0	0	2768607	0		0		
2012	4	5923	5	21322	0	0	0	0	5682367	0		0		
2013	2	5096	16	60923	0	0	0	0	7713556	0		0		
2013	3	3026	1	7690	0	0	0	0	2727707	0		0		
2013	4	5326	11	29517	0	0	0	0	5764340	0		0		
2014	2	6021	34	123712	0	0	0	0	10373892	0		0		
2014	3	3051	14	17916	0	0	0	0	4186981	0		0		
2014	4	5700	64	225088	0	0	0	0	7450102	0		0		
2015	2	4967	85	272510	0	0	0	0	4903331	0		0		
2015	3	2865	43	97006	0	0	0	0	1432352	0		0		
2015	4	5256	108	371674	0	0	0	0	5169374	0		0		
2016	2	4863	138	457929	0	0	0	0	5840419	0		0		
2016	3	1756	56	90018	1	5.2	0.0000111	0.0000578	547035	6	33.71	31.6	911.40	
2016	4	4955	133	455042	0	0	0	0	5306585	0		0		
2017	2	4057	146	557682	0	0	0	0	5288137	0		0		
2017	3	1097	110	96189	1	4	0.0000104	0.0000416	653270	7	39.87	27.2	637.87	
2017	4	3971	117	374109	0	0	0	0	4397068	0		0		
2018	2	4540	118	366457	0	0	0	0	5575831	0		0		
2018	3	1635	51	43868	4	275.8	0.0000912	0.0062871	635758	58	1670.24	3997.1	11585226.39	
2018	4	3952	143	490426	0	0	0	0	4879517	0		0		
				AVE			0.0000139	0.0001109						

Appendix 1. Table 3. Live discard ratios and estimated quarterly discards for the analyses excluding all discards from observed trips that had large numbers of small (<40 cm fork length) blacktip sharks reported.

year	qtr	total trips	OBS catch kept	OBS total live disc	weight live disc	numbers live d/k	weight live d/k	total catch kept	est number live disc	variance	est weight live disc	variance
1995	2	3850	77	187452	0	0	0	0	5396578	0		0
1995	3	1262	49	76520	0	0	0	0	3161014	0		0
1995	4	3103	99	235888	0	0	0	0	4088671	0		0
1996	2	4245	71	195625	0	0	0	0	8189278	0		0
1996	3	1403	47	62888	0	0	0	0	5708407	0		0
1996	4	3457	71	187467	0	0	0	0	2103300	0		0
1997	2	5083	69	229396	0	0	0	0	6188031	0		0
1997	3	3280	32	53592	3	50.2	0.0000560	0.0009367	4678742	262	34897.52	4382.6
1997	4	4648	58	160402	0	0	0	0	6784403	0		0
1998	2	8476	37	103860	0	0	0	0	9581733	0		0
1998	3	5897	8	3558	0	0	0.0000000	0.0000000	4188345	0		0
1998	4	9155	40	76843	0	0	0	0	9522026	0		0
1999	2	10802	21	24139	0	0	0	0	9358133	0		0
1999	3	6114	13	8628	2	14	0.0002318	0.0016227	3684094	854	755723.53	5978.2
1999	4	9256	26	23416	0	0	0	0	6688222	0		0
2000	2	11609	20	18055	0	0	0.0000000	0.0000000	6724732	0		0
2000	3	7831	10	20817	1	13	0.0000480	0.0006245	5179659	249	68661.62	3234.6
2000	4	5897	36	55917	0	0	0	0	5928571	0		0
2001	2	6956	26	44253	0	0	0	0	6332842	0		0
2001	3	5068	6	4035	0	0	0.0000000	0.0000000	4170681	0		0
2001	4	7091	20	24355	0	0	0	0	7385652	0		0
2002	2	7219	13	17231	0	0	0	0	6573098	0		0
2002	3	7511	6	3374	0	0	0	0	4232936	0		0
2002	4	9713	17	23175	0	0	0	0	5813928	0		0
2003	2	9155	17	24521	0	0	0.0000000	0.0000000	4694900	0		0
2003	3	4922	8	8670	0	0	0	0	8833809	0		0
2003	4	8292	5	20187	0	0	0	0	3618204	0		0
2004	2	4831	1	3067	0	0	0	0	6489018	0		0
2004	3	3163	1	18	0	0	0	0	3779103	0		0
2004	4	5053	40	54271	0	0	0	0	4548382	0		0
2005	2	5218	57	139214	0	0	0	0	4049135	0		0
2005	3	3664	2	6036	0	0	0	0	1799729	0		0
2005	4	4528	16	42410	0	0	0	0	2800927	0		0
2006	2	4273	8	17939	0	0	0	0	3883817	0		0
2006	3	2786	1	1952	0	0	0	0	1802977	0		0
2006	4	4203	5	10378	0	0	0	0	2763622	0		0
2007	2	4695	12	31824	0	0	0	0	6741640	0		0
2007	3	3805							3972633	0		0
2007	4	6537	16	25623	0	0	0	0	6621164	0		0
2008	2	4610	10	29273	0	0	0	0	6734243	0		0
2008	3	2340	5	9394	0	0	0	0	3306429	0		0
2008	4	4311	17	34898	0	0	0	0	5112737	0		0
2009	2	5423	17	36837	0	0	0	0	7771602	0		0
2009	3	4412							4373842	0		0
2009	4	5273	15	31220	0	0	0	0	6108853	0		0
2010	2	4575	47	169453	0	0	0	0	5549074	0		0
2010	3	3277	2	1220			0	0	2021831	0		0
2010	4	4561	59	152352	0	0	0	0	3297244	0		0
2011	2	5821	25	67410	0	0	0	0	7240723	0		0
2011	3	4108	2	0	0	0	0	0	4220932	0		0
2011	4	7063	19	71529	0	0	0	0	8360466	0		0
2012	2	3238	55	284376	0	0	0	0	7450971	0		0
2012	3	3382	1	457	0	0	0	0	2768607	0		0
2012	4	5923	5	21322	0	0	0	0	5682367	0		0
2013	2	5096	16	60923	0	0	0	0	7713556	0		0
2013	3	3026	1	7690	0	0	0	0	2727707	0		0
2013	4	5326	11	29517	0	0	0	0	5764340	0		0
2014	2	6021	34	123712	0	0	0	0	10373892	0		0
2014	3	3051	14	17916	0	0	0	0	4186981	0		0
2014	4	5700	64	225088	0	0	0	0	7450102	0		0
2015	2	4967	85	272510	2	4	0.0000073	0.0000147	490331	36	1286.04	72.0
2015	3	2865	43	97006	0	0	0	0	1432352	0		0
2015	4	5256	108	371674	0	0	0	0	5169374	0		0
2016	2	4863	138	457929	0	0	0	0	5840419	0		0
2016	3	1756	56	90018	0	0	0	0	547035	0		0
2016	4	4955	133	455042	1	40	0.0000022	0.00000879	5306585	12	133.10	466.5
2017	2	4057	146	557682	0	0	0	0	5288137	0		0
2017	3	1097	110	96189	0	0	0	0	653270	0		0
2017	4	3971	117	374109	0	0	0	0	4397068	0		0
2018	2	4540	118	366457	0	0	0	0	5575831	0		0
2018	3	1635	51	43868	1	3.8	0.0000228	0.00000866	635758	14	204.34	55.1
2018	4	3952	143	490426	0	0	0	0	4879517	0		0
				AVE	0.0000053	0.0000482						

Appendix 1. Table 4. Dead discard ratios and estimated quarterly discards for the analyses excluding all discards from observed trips that had large numbers of small (<40 cm fork length) blacktip sharks reported.

year	qtr	total trips	OBS trips	OBS total catch kept	numbers dead	weight disc	numbers dead d/k	weight dead d/k	total catch kept	est number dead disc	variance	est weight dead disc	variance
1995	2	3850	77	187452	0	0	0	0	5396578	0		0	
1995	3	1262	49	76520	0	0	0	0	3161014	0		0	
1995	4	3103	99	235888	0	0	0	0	4088671	0		0	
1996	2	4245	71	195625	0	0	0	0	8189278	0		0	
1996	3	1403	47	62888	0	0	0	0	5708407	0		0	
1996	4	3457	71	187467	0	0	0	0	2103300	0		0	
1997	2	5083	69	229396	0	0	0	0	6188031	0		0	
1997	3	3280	32	53592	0	0	0	0	4678742	0		0	
1997	4	4648	58	160402	0	0	0	0	6784403	0		0	
1998	2	8476	37	103860	0	0	0	0	9581733	0		0	
1998	3	5897	8	3558	0	0	0	0	4188345	0		0	
1998	4	9155	40	76843	5	9.1	0.0000651	0.0001184	9522026	620	386771.26	1127.6	1281198.76
1999	2	10802	21	24139	0	0	0	0	9358133	0		0	
1999	3	6114	13	8628	2	6	0.0002318	0.0006954	3684094	854	370075.16	2562.1	3750403.17
1999	4	9256	26	23416	0	0	0	0	6688222	0		0	
2000	2	11609	20	18055	0	0	0	0	6724732	0		0	
2000	3	7831	10	20817	0	0	0	0	5179659	0		0	
2000	4	5897	36	55917	0	0	0	0	5928571	0		0	
2001	2	6956	26	44253	0	0	0	0	6332842	0		0	
2001	3	5068	6	4035	0	0	0	0	4170681	0		0	
2001	4	7091	20	24355	0	0	0	0	7385652	0		0	
2002	2	7219	13	17231	0	0	0	0	6573098	0		0	
2002	3	7511	6	3374	0	0	0	0	4232936	0		0	
2002	4	9713	17	23175	0	0	0	0	5813928	0		0	
2003	2	9155	17	24521	0	0	0	0	4694900	0		0	
2003	3	4922	8	8670	0	0	0	0	8833809	0		0	
2003	4	8292	5	20187	0	0	0	0	3618204	0		0	
2004	2	4831	1	3067	0	0	0	0	6489018	0		0	
2004	3	3163	1	18	0	0	0	0	3779103	0		0	
2004	4	5053	40	54271	0	0	0	0	4548382	0		0	
2005	2	5218	57	139214	0	0	0	0	4049135	0		0	
2005	3	3664	2	6036	0	0	0	0	1799729	0		0	
2005	4	4528	16	42410	0	0	0	0	2800927	0		0	
2006	2	4273	8	17939	0	0	0	0	3883817	0		0	
2006	3	2786	1	1952	0	0	0	0	1802977	0		0	
2006	4	4203	5	10378	0	0	0	0	2763622	0		0	
2007	2	4695	12	31824	0	0	0	0	6741640	0		0	
2007	3	3805							3972633	0		0	
2007	4	6537	16	25623	0	0	0	0	6621164	0		0	
2008	2	4610	10	29273	0	0	0	0	6734243	0		0	
2008	3	2340	5	9394	0	0	0	0	3306429	0		0	
2008	4	4311	17	34898	0	0	0	0	5112737	0		0	
2009	2	5423	17	36837	0	0	0	0	7771602	0		0	
2009	3	4412							4373842	0		0	
2009	4	5273	15	31220	0	0	0	0	6108853	0		0	
2010	2	4575	47	169453	0	0	0	0	5549074	0		0	
2010	3	3277	2	1220					2021831	0		0	
2010	4	4561	59	152352	0	0	0	0	3297244	0		0	
2011	2	5821	25	67410	0	0	0	0	7240723	0		0	
2011	3	4108	2	0	0	0	0	0	4220932	0		0	
2011	4	7063	19	71529	0	0	0	0	8360466	0		0	
2012	2	3238	55	284376	0	0	0	0	7450971	0		0	
2012	3	3382	1	457	0	0	0	0	2768607	0		0	
2012	4	5923	5	21322	0	0	0	0	5682367	0		0	
2013	2	5096	16	60923	0	0	0	0	7713556	0		0	
2013	3	3026	1	7690	0	0	0	0	2727707	0		0	
2013	4	5326	11	29517	0	0	0	0	5764340	0		0	
2014	2	6021	34	123712	0	0	0	0	10373892	0		0	
2014	3	3051	14	17916	0	0	0	0	4186981	0		0	
2014	4	5700	64	225088	0	0	0	0	7450102	0		0	
2015	2	4967	85	272510	0	0	0	0	4903331	0		0	
2015	3	2865	43	97006	0	0	0	0	1432352	0		0	
2015	4	5256	108	371674	0	0	0	0	5169374	0		0	
2016	2	4863	138	457929	0	0	0	0	5840419	0		0	
2016	3	1756	56	90018	1	5.2	0.0000111	0.0000578	547035	6	33.71	31.6	911.40
2016	4	4955	133	455042	0	0	0	0	5306585	0		0	
2017	2	4057	146	557682	0	0	0	0	5288137	0		0	
2017	3	1097	110	96189	1	4	0.0000104	0.0000416	653270	7	39.87	27.2	637.87
2017	4	3971	117	374109	0	0	0	0	4397068	0		0	
2018	2	4540	118	366457	0	0	0	0	5575831	0		0	
2018	3	1635	51	43868	4	275.8	0.0000912	0.0062871	635758	58	1670.24	3997.1	11585226.39
2018	4	3952	143	490426	0	0	0	0	4879517	0		0	
				AVE	0.0000059	0.0001029							