Bycatch estimates of blacktip shark in the shark bottom longline fishery

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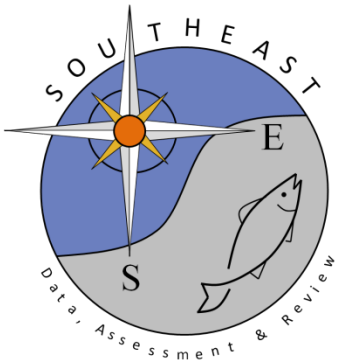

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Introduction

Currently about 200 United States (US) fishers are permitted to target sharks (excluding dogfish) in the Atlantic Ocean and Gulf of Mexico, with an additional number of fishers (<250) permitted to land sharks incidentally. Amendments to the Consolidated Atlantic Highly Migratory Species Fishery Management Plan based on stock assessments have eliminated the major directed shark fishery in the US South Atlantic (NMFS 2007). These amendments also implemented a shark research fishery, which allows the National Marine Fisheries Service (NMFS) to select a limited number of commercial shark vessels on an annual basis to collect life history data and catch data for future stock assessments. Since 2008, only commercial shark fishers participating in the shark research fishery are allowed to land sandbar sharks, *Carcharhinus plumbeus*, and must carry an observer on 100% of all trips (compared to a coverage level of 4-6% outside the research fishery). Fishers not participating in the research fishery are permitted to land 45 non-sandbar large coastal sharks (including blacktip shark, *Carcharhinus limbatus*, bull shark, *Carcharhinus leucas*, lemon shark, *Negaprion brevirostris*, nurse shark, *Ginglymostoma cirratum*, silky shark, *Carcharhinus falciformis*, spinner shark, *Carcharhinus brevipinna*, tiger shark, *Galeocerdo cuvier*, great hammerhead, *Sphyrna mokarran*, and scalloped hammerhead, *Sphyrna lewini*) per trip in the South Atlantic region.

Bottom longline landings and fishing effort of commercial vessels operating in the South Atlantic are reported to NMFS through the Coastal Fisheries Logbook Program (CFLP, conducted by the NMFS Southeast Fisheries Science Center). The program collects landings and effort data by fishing trip from vessels that are federally permitted to fish in a number of fisheries managed by NMFS and South Atlantic Fishery Management Council. The coastal logbook program began in 1990 with the objective of a complete census of coastal fisheries permitted vessel activity, with the exception of Florida, where a 20% sample of vessels was selected to report. Beginning in 1993, reporting in Florida was increased to include all vessels permitted for federally managed coastal fisheries.

Commercial shark longline vessels operating in the US South Atlantic are also required to carry fishery observers to monitor catch and bycatch. Fishery observers are trained in fishery and biological data collection, biological sampling, and teleost and elasmobranch species identification. Observers are required to record and measure all species captured, their disposition (e.g. kept, discarded dead, used for bait, etc.) and effort (e.g. number of hooks, gear characteristics, set and haul times).

Methods

Estimates of dead and live discards were reported separately for the shark research fishery and the shark bottom longline fishery. As vessels in the shark research fishery are monitored 100%, no extrapolations of the dead discards were needed.

For vessels outside the shark research fishery (i.e. shark bottom longline fishery), observer-reported blacktip shark discard rates from 2006-2018, along with self reported commercial fishing effort data, were used to calculate blacktip shark discards for the shark bottom longline fishery in the US South Atlantic. Following the definition of the South Atlantic from the Highly Migratory Species Office, data were excluded from the Gulf of Mexico. Due to the nature of the

data, we followed the approach of Garrison (2007) by employing a simple ratio estimator to represent bycatch rates:

Catch per unit effort (CPUE) = number of blacktip sharks discarded / number of hooks fished

An estimate of uncertainty in these estimates was derived from bootstrap resampling of the calculated CPUE data set. A sample was drawn from the data (with replacement) and the procedure was repeated 10,000 times to generate a mean distribution for the estimate and the associated standard deviation. Estimates were derived separately for sharks discarded dead and sharks discards alive as reported by the on-board observer.

Fishing effort data were available from the coastal logbook program for the years 1993-2016 (Figure 1). Beginning in 1993 all commercial vessels with Federal fishing permits (other than those for swordfish, tunas, and shrimp) was required to report landings and effort to the coastal logbook program. Available coastal logbook data were filtered to include only bottom longline data and to remove records missing effort information (number of sets, number of hooks per set). Data reported from individual trips with fishing effort in both the South Atlantic and Gulf of Mexico were excluded from the analyses because fishing effort cannot be reliably apportioned within single trips. Coastal logbook data were additionally filtered to remove likely erroneous records; for example, data from trips that reported fishing more than 24 sets per 24 hours. Those data that exceeded the 99.5 percentile of the data for any variable used to calculate effort (number of sets, number of hooks) were also excluded. Such outliers in the data set usually resulted from data entry errors. After data filtering, effort data from only those trips that targeted sharks (defined as trips with reported landings of 2/3 shark by weight) were included in the analysis. Effort was defined as hooks fished because hook hours fished could not be reliably calculated from the coastal logbook data.

Total discards were calculated as the product of observer reported yearly mean dead and live discard rates by hook and the yearly total fishing effort (bottom longline hooks) reported to the coastal logbook program. As the logbook data does not differentiate vessels in the research fishery, total fishing effort from 2008-2018 was estimated by subtracting the effort observed (100%) in the research fishery from the effort estimated in the logbooks.

To calculate discards for the years 1993-2005, when the Panama City observer program made no observer trips, the mean discard rate was used. In a year where no observations were made outside the shark research fishery or sample size was low (e.g., $n \leq 5$), the mean discard rate from 2006-2018 was used.

Results and Discussion

Calculated blacktip shark dead discards (in numbers of sharks) from commercial shark bottom longline fishery and the shark research fishery are provided in Table 1 and 2, respectively. Calculated blacktip shark live discards (in numbers of sharks) from commercial shark bottom longline fishery and the shark research fishery are provided in Table 3 and 4, respectively. In all the estimates, data was pooled without considering strata due to the sparse nature of the bycatch events and the fact that logbook data is reported by sampling grid (see Figure 1).

Table 1. Yearly calculated dead discards of blacktip sharks for the shark bottom longline fishery. Discards are reported as number.

Year	Number Observed Sets	Mean Discard Rate	Standard deviation	Total hooks	Total Dead Discards
1993		0.00670		373270	2,499
1994		0.00670		767570	5,139
1995		0.00670		293603	1,966
1996		0.00670		853758	5,717
1997		0.00670		393413	2,634
1998		0.00670		458687	3,071
1999		0.00670		420234	2,814
2000		0.00670		398160	2,666
2001		0.00670		432662	2,897
2002		0.00670		583965	3,910
2003		0.00670		586888	3,930
2004		0.00670		455745	3,052
2005		0.00670		386396	2,587
2006	36	0.00004	0.00018	386212	16
2007	35	0.00007	0.00030	207548	14
2008	5	0.00670		112946	756
2009	2	0.00670		252278	1,689
2010	2	0.00670		209491	1,403
2011	12	0.00792	0.01014	150252	1,190
2012	21	0.00439	0.01084	88786	390
2013	20	0.00824	0.02067	126843	1,045
2014	22	0.00620	0.01193	173177	1,074
2015	8	0.01385	0.03059	155914	2,159
2016	14	0.01110	0.01998	92890	1,031
2017	13	0.00847	0.01750	97453	825
2018	0	0.00670		71537	479

Table 2. Yearly observed dead discards of blacktip sharks from shark research fishery. Discards are reported as number.

Year	Number Observed Sets	Total Dead Discards
2008	21	13
2009	40	8
2010	127	18
2011	141	56
2012	58	0
2013	47	2
2014	88	2
2015	60	1
2016	52	4
2017	49	4
2018	57	0

Table 3. Yearly calculated live discards of blacktip sharks for the shark bottom longline fishery. Discards are reported as number.

Year	Number Observed Sets	Mean Discard Rate	Standard deviation	Total hooks	Total Live Discards
1993		0.0003		373270	116
1994		0.0003		767570	239
1995		0.0003		293603	91
1996		0.0003		853758	266
1997		0.0003		393413	122
1998		0.0003		458687	143
1999		0.0003		420234	131
2000		0.0003		398160	124
2001		0.0003		432662	135
2002		0.0003		583965	182
2003		0.0003		586888	183
2004		0.0003		455745	142
2005		0.0003		386396	120
2006	36	0.0000	0.0000	386212	0
2007	35	0.0000	0.0000	207548	0
2008	5	0.0003		112946	35
2009	2	0.0003		252278	78
2010	2	0.0003		209491	65
2011	12	0.0001	0.0003	150252	19
2012	21	0.0000		88786	0
2013	20	0.0000		126843	0
2014	22	0.0002	0.0006	173177	31
2015	8	0.0004	0.0011	155914	62
2016	14	0.0003	0.0008	92890	25
2017	13	0.0018	0.0045	97453	179
2018	0	0.0003		71537	22

Table 4. Yearly observed live discards of blacktip sharks from shark research fishery. Discards are reported as number.

Year	Number Observed Sets	Total Live Discards
2008	21	1
2009	40	1
2010	127	9
2011	141	16
2012	58	0
2013	47	0
2014	88	0
2015	60	0
2016	52	0
2017	49	0
2018	57	0

Figure 1. Coastal logbook statistical areas.