Estimated Takes of Protected Species in the Commercial Directed Shark Bottom Longline Fishery 2006.

National Marine Fisheries Service
Southeast Fisheries Science Center
75 Virginia Beach Drive
Miami, FL 33149

November, 2007
NMFS Southeast Fisheries Science Center Contribution PRBD-07/08-05

This report estimates total takes of protected species in the U.S. Atlantic commercial directed shark bottom longline fishery for 2006. This report follows a prior report for estimated takes in this same fishery for 2003 thru 2005 (Richards 2006), using the same basic methods and written format. For the purposes of consistency, much of the structure and prose are identical to the prior report (Richards 2006), except where methods and estimates have changed. All catch rates were estimated in identical ways to the previous report, except for dropping pooled estimates because they are very difficult to justify (see Richards 2006).

For the purposes of this report, takes of protected species (hereafter "takes") refers to protected species that were incidentally captured during fishing operations. The commercial directed shark bottom longline fishery is comprised of those fishers that hold directed shark permits. For consistency with prior estimates made in a 2003 Biological Opinion[1], and Richards (2006) we attempted to follow the same methods, but this was not always possible, or desirable.

Methods

Estimates of total takes in this report were based upon self reported effort from both the coastal and pelagic longline fishery logbook programs, which are part of the Fishery Logbook database (FLS) at the Southeast Fisheries Science Center (SEFSC). Both directed and incidental permit holders report their activities to the FLS without reference to the permit type they are operating under, nor to the target fishery in the trip based coastal logbook program. The total bottom longline effort within the coastal logbook was allocated to the shark directed, other catch (e.g. reef fish, tilefish, etc.), and effort of those with shark permits whose trips could not be allocated to either shark directed or other catch. Allocation of effort to the directed portion of the fishery was based upon directed shark permits (from the Southeast Regional Offices (SERO) permit database), and expert opinion about what comprises a shark trip (that 2/3 of landings by weight were sharks). We also removed questionable data trips; those trips with less than 30 hooks per set and trips with sets greater than 25 miles in length (both were in the lower or upper 0.25% of the data).

To determine participation in the shark bottom longline fishery from the trip based coastal logbook program, we assumed that effort was a part of the fishery if the fishers reported using bottom longline gear, were in possession of a directed shark permit, and landings were greater than 2/3 by weight of sharks. Allocation to other catch was the sum of effort of those without directed shark permits and those with directed shark permits whose catch was greater than 2/3 by weight of species other than sharks. All other effort was unallocated, that is those with directed shark permits, but did not either catch at least 2/3 by weight sharks or 2/3 by weight species other than sharks. For the set based pelagic longline logbook, we selected bottom longline sets by fishers with directed shark permits that targeted sharks. We also removed two duplicate reports between the two data sets.

To determine fishing regions we accepted the classification by statistical areas recorded in the coastal logbook database and the statistical areas defined by the pelagic longline

fishery (SA is east of 83° W longitude). We accepted the classification by region made by the SEFSC Panama City Laboratory observer program (Table 1) for observed effort and takes of protected species other than sea turtles, and the Sea Turtle Life History HMS Database for takes of sea turtles.

Estimation of the total fishery effort for extrapolation from the observed takes to total estimated takes was constrained by the information consistently and reliably reported in common between the two sources of logbook data, and the two sources of observation data, one for observed effort and takes of animals other than sea turtles and the other for takes of sea turtles. For this analysis we used two measures of effort, set and number of hooks in a set. A combination of the binomial model and the effort variables set and hooks was used for estimation of takes for years prior to 2003[1]. The use of hooks as an effort variable (and thus the use of the delta lognormal model, as opposed to the binomial model applied to sets) was due in part to the use of this effort parameter and analysis type in a similar fishery, the pelagic longline (see Johnson et al. 1999, Walsh and Garrison 2005).

Records of observed effort and takes for the commercial directed shark bottom longline fishery came from the SEFSC observer program (formerly named "Commercial Shark Fishery Program") database (Hale and Carlson 2007). This program in 2006 attempted to randomly select vessels for observation from those that use bottom longline gear (Hale and Carlson 2007), The fishery was observed in two general regions, the "South Atlantic" (SA) region (defined in Smith et al. 2006 as the eastern U.S. coast from North Carolina to the Florida Keys [not the South Atlantic Ocean]), and the Gulf of Mexico (GOM) region (along the coast from Texas to South Florida). No observations were made in the "North Atlantic" (NA), therefore all take estimates would be zero and the reported effort (19 shark trips of 5,922 hooks) from this region was removed for this report. In this analysis, seasons are based on the Large Coastal Shark Complex Season dates for 2006. Season 1 was defined as January 1 through either April 15 for the Gulf of Mexico (GOM), March 15 for the "South Atlantic" (SA), and season 2 as July 6 through either July 31 for the GOM, August 16 for the SA, and season 3 as September 1 through either November 7 for the GOM, or October 3 for the SA.

The observer program tracked effort and takes by region and by season which could be justified for several reasons: (1.) The two regions differed in common fishing practices (Smith et al. 2006) including hook size, which has been shown to have a significant effect on sea turtle capture in another longline fishery (Watson et al. 2004); (2.) It seems reasonable to expect the protected species caught in this fishery to differ in their abundances and distributions between regions and seasons; and (3.) This information could be useful for tracking the management of the fishery. All analysis followed the observer program design. Although pooling the data across stratifications of season and region might be justified to reduce the sparseness of the data, such pooling may not be

[1] Biological Opinion on the continued operation of Atlantic shark fisheries (commercial shark bottom longline and drift gillnet fisheries and recreational shark fisheries) under the Fishery Management Plan for Atlantic Tunas, Swordfish, and Sharks (HMS FMP) and the Proposed Rule for Draft Amendment 1 to the HMS FMP, July 2003.

appropriate because it would ignore the non-random distribution of the species incidentally captured, and the differential operation of the fishery between areas.

The standard binomial model was used to estimate probability and the coefficient of variation (CV) of capture per set. The 95% confidence intervals were estimated using the "Wilson" interval, which has been shown to have a reasonable coverage particularly for extreme probabilities (see Brown et al. 2001). It should be noted, however, that the estimation of confidence intervals for the binomial are fraught with problems, especially for sparse data sets (see Brown et al 2001, and subsequent arguments).

A delta lognormal approach (Pennington 1983) was used to estimate the mean and variance of takes per hook per set. This method combines a binomial model for the total observations with a lognormal model for the non-zero catch per unit effort (CPUE) data, which are assumed to be lognormally distributed. Extrapolated takes by the fishery were the multiplication of either catch per hook or probability of catch per set by the appropriate units of total effort (hook or set) extracted from the logbooks.

Estimation of total takes could be done for several levels of stratification: By season, region, and release condition, and classified by either hook or by set. Release condition for two loggerheads was problematic. The observer originally coded and noted that the turtles release condition was unknown (also reported in Hale and Carlson 2007), after resuscitation attempts onboard. They did report minimal responsiveness before release. Upon review by database management and consulted professionals, the coding was changed to discarded marked, unresponsive carcass (Appendix A). Due to the sparseness of the data, we have elected to not further stratify the data by release condition of the loggerhead sea turtles (alive, dead, or some other category) to estimate total takes. Because the final estimate of total takes could be sensitive to choice of effort variable and analysis method, we estimated extrapolated takes of each species two ways for comparison: classifying effort either by hook or by set, stratified by region, and season. Annual sums of stratified estimates were also calculated wherever possible.

Results and Discussion

There were a total of 7 observed takes of all protected species in 2006, two smalltooth sawfish (*Pristis pectinata*), and 5 loggerhead turtles (*Caretta caretta*) (Table 1, Figures 1, and Appendix A). Both captured sawfish were released alive, one loggerhead sea turtle was dead, two were released alive, and two others were released in a compromised state but, from an interpretation of the written observer comments, seemed unlikely to survive.

In our attempt to allocate all bottom longline effort within the coastal logbook to either directed shark or other catch, we found that the effort we could not allocate to either category was overall relatively small, between 1.3% and 2.6% of all bottom longline effort (trip, set, or hook) by region. As a proportion of the shark directed effort, the unallocated effort was similarly small in the SA (7.5% by set and 7.4% by hook), but rather large (47.2% by set and 80.4% by hook) in the GOM. In either case this potentially indicates an underestimate of the total directed shark effort.

Total fishery effort is summarized in Table 2 and observed effort is summarized in Table 3. These tables, together with the table of observed takes (Table 1) provide all information needed to produce the extrapolated estimated takes presented in Tables 4 and 5. Comparing the estimated total takes using different approaches demonstrates the degree to which the choice of effort variables affects the extrapolated estimates of total takes. The different estimates were not very consistent for any of the protected species examined in this report (Tables 4 and 5) which inspires little confidence in their accuracy. Additionally, precision of these estimates was not particularly good in most of cases, and never achieved the NMFS recommended goal of a 20-30% CV (NMFS, 2004).

In all the estimates presented in Tables 4 and 5, very sparse data were used to produce results. Sparse data are not likely to fit a critical assumption of the delta lognormal model (Pennington 1983) that the non-zero CPUE's are drawn from a lognormal distribution. One could argue that the sample could have been drawn from a larger population of captures within the fishery, and that this larger population was lognormally distributed. In any case, the extrapolated estimates based upon sparse data sets should not be assumed to be reasonable without potentially invoking large assumptions regarding unobserved events.

It is difficult to recommend using a specific effort variable; although it does seem reasonable that something beyond set would affect capture of protected resources. However, it may be equally reasonable that if a protected species was available to the gear, the catchability was 1.0, no matter what the total number of hooks in the set was. Other more important factors such as local habitat characteristics (temperature, location, etc), or characteristics of the target catch, may be the variable of interest. Only well controlled, fisheries independent, studies would be likely to be able to determine the importance of these other factors. Other measures of effort could be used, (such as trip), but other than further demonstrating the uncertainty associated with analysis of sparse data from surveys conduced for multiple purposes, there are no compelling reasons to explore any other measures of effort and the fundamental conclusion of this analysis (that sparse data is the primary problem) will not change.

The rarity of capture events was a serious problem for interpretation of extrapolated takes because estimates based on only one or a few captures are not confidence inspiring. Therefore, we would recommend excluding all estimates made with CV's =1.00 from management decisions. This problem has been wrestled with by NMFS before (see Appendix A, NMFS, 2004), and although they recommended using bycatch estimates with a CV of 20 or 30%, they also noted that in many rare event cases this might require 80-90% observer coverage.

Extrapolation that assumes capture is directly related to effort becomes particularly problematic when extrapolating across large spatial areas. Although a potential problem for both of the protected species considered in this report, and part of the rational for stratifying analyses by region, it is particularly odd to extrapolate takes even within region for the smalltooth sawfish. The bulk of the smalltooth sawfish population is

thought to reside in the region near the Everglades. For the single capture event of two smalltooth sawfish in the SA in 2006 (Table 1, Figure 1) extrapolating to the entire SA region potentially introduces a gross positive bias to the estimate presented in Table 4, and one could argue that extrapolation should have been conducted over a much smaller region. Extrapolated estimates for both of the protected species considered in this report may have similar issues. We have no recommendation of how to rectify this problem with the given data without making an arbitrary managerial decision about where and how to define the area of equal catchablity of sawfish, or other protected species, within the region of the shark bottom longline fishery operation.

Acknowledgements

Thanks to Guillermo Diaz, Kevin McCarthy, John Carlson, Steve Turner, Lori Hale, Jennifer Lee, Lesley Stokes, and Sheryan Epperly for facilitating getting all the various SEFSC data sets to us. We thank Janet L. Miller and Carolyn Sramek for SERO commercial directed shark permit information.

Literature Cited

Brown, L. D., T. T. Cai, and A. DasGupta. 2001. Interval estimation for a binomial proportion. Statistical Science 16(2):101-133.

Burgess, G. H. and A. Morgan. 2003. Commercial shark fishery observer program. Renewal of an observer program to monitor the directed commercial shark fishery in the Gulf of Mexico and the south Atlantic: 2002(2) and 2003(1) fishing seasons. Final Report, U.S. National Marine Fisheries Service, Highly Migratory Species Management Division Award NA16FM1598, 15p.

Hale, L.F., and J.K. Carlson. 2007. Characterization of the shark bottom longline fishery: 2005-2006. NOAA Technical Memorandum NMFS-SEFSC-554, 28p.

Johnson, D.R., C. Yeung, and C.A. Brown. 1999. Estimates of marine mammal and marine turtle bycatch by the U.S. Atlantic pelagic longline fleet in 1992-1997. NOAA Technical Memorandum NMFS-SEFSC-418: 70 p.

NMFS (National Marine Fisheries Service). 2004. Evaluating bycatch: a national approach to standardized bycatch monitoring programs. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-66, 108 p.

Pennington, M. 1983. Efficient estimators of abundance for fish and plankton surveys. Biometrics 39: 281-286.

Richards, P. M. 2007. Estimated takes of protected species in the commercial directed shark bottom longline fishery 2003, 2004, and 2005. NMFS Southeast Fisheries Science Center Contribution PRD-06/07-08, June 2007, 21 p.

Smith, P. C., L. F. Hale, and J. K. Carlson. 2006. The directed shark longline fishery: catch and bycatch, 2005. NMFS Panama City Laboratory Contribution 06-04. 15 p.

Walsh, C. Fairfield and L. P. Garrison. 2006. Estimated bycatch of marine mammals and turtles in the U.S. Atlantic pelagic longline fleet during 2005. NOAA Technical Memorandum NMFS-SEFSC-539, 52pp.

Watson, J. W., S.P. Epperly, A.K. Shah, and D.G. Foster. 2004. Fishing methods to reduce sea turtle mortality associated with pelagic longlines. Canadian Journal of Fisheries and Aquatic Sciences 62:965-981.

Figure 1: Observed sets (n = 83) and takes of six protected species for 2006. The southern most loggerhead capture event in the Atlantic represents 2 captures in a single set, and the smalltooth sawfish event represents 2 captures in a single set, all others represent a single capture event.

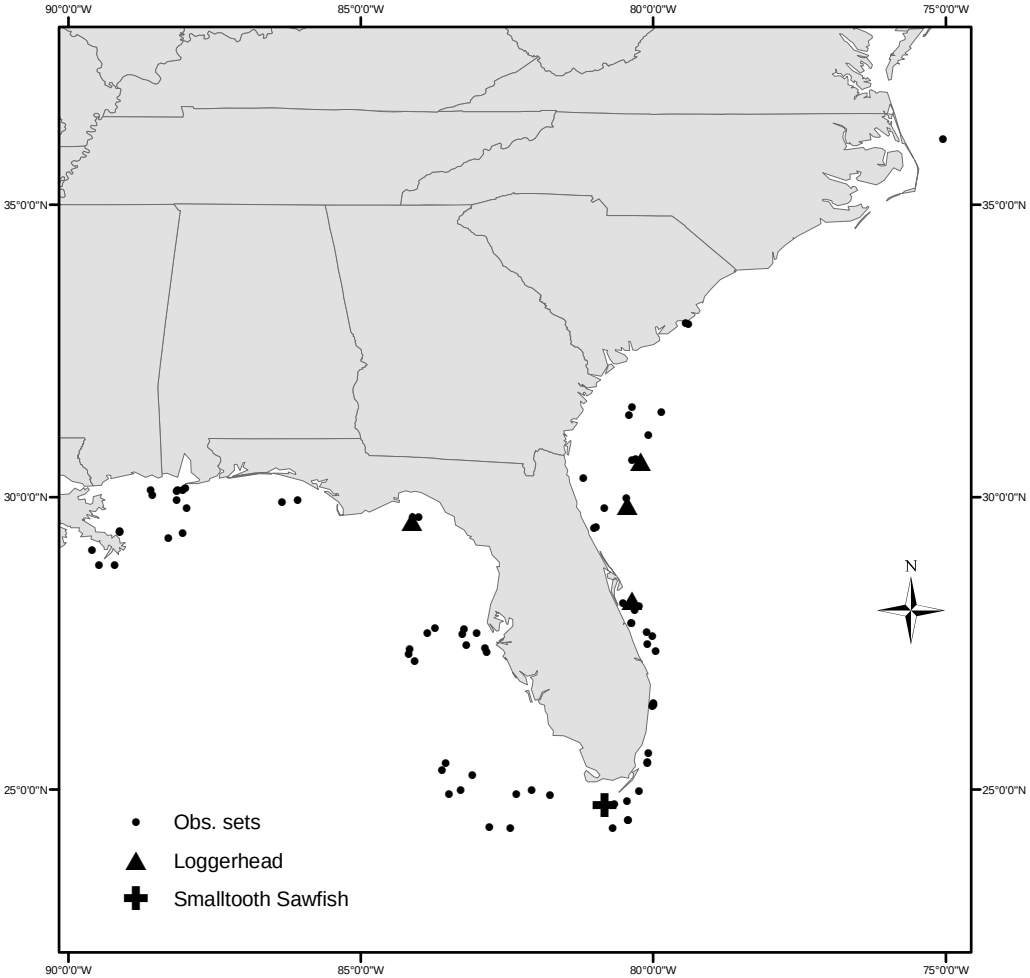

Table 1: Observed takes by fishers targeting sharks with commercial directed shark fishing permits of loggerhead turtles and smalltooth sawfish, by set. GOM = Gulf of Mexico, SA = "South Atlantic" (as defined for this fishery in Smith et al. 2006). Summary of data from the SEFSC observer database.

Set Id.	Region	Season	Hooks	Species	Number	Condition
1	SA	1	995	Loggerhead	1	*
2	SA	1	471	Loggerhead	1	*
2	SA	1	471	Loggerhead	1	*
3	SA	2	243	Loggerhead	1	*
4	GOM	3	524	Loggerhead	1	*
5	SA	1	355	Smalltooth Sawfish	2	Alive

* See Appendix A for interpreted observer data

Table 2: Combined reported effort in sets and hooks from the Southeast Fisheries Science Centers coastal and pelagic longline logbooks for fishing vessels listed in the Southeast Regional Offices permit database as having a commercial directed shark permit, that used bottom longline gear, and either landed at least 2/3 by weight of sharks, or reported targeting sharks, by region, and season.

2a. Reported sets

Season	**Gulf of Mexico**	**"South Atlantic"**	**Row Totals**
1	626	331	957
2	419	267	686
3	548	101	649
Closed	41	12	53
Total	1,634	711	2,345

2b. Reported hooks

Season	**Gulf of Mexico**	**"South Atlantic"**	**Row Totals**
1	451,910	181,022	632,932
2	341,206	155,724	496,930
3	406,590	68,246	474,836
Closed	18,600	6,450	25,050
Total	1,218,306	411,442	1,629,748

Table 3: Observed effort in sets and hooks for fishers targeting sharks with commercial directed shark fishing permits by region, and season.

3a: Sets

Season	**Gulf of Mexico**	**"South Atlantic"**	**Row Totals**
1	8	26	34
2	19	9	28
3	14	7	21
closed	0	0	0
Totals	41	42	83

3b: Hooks

Season	**Gulf of Mexico**	**"South Atlantic"**	**Row Totals**
1	3761	14834	18595
2	11277	5051	16328
3	8581	2417	10998
closed	0	0	0
Totals	23619	22302	45921

Table 4. Estimated live takes of smalltooth sawfish for 2006 in the commercial directed shark bottom longline fishery. All values in this table are based on 2 captures in a single set.

Area	Season	Takes	95% CI	CV
Analyzed by set				
SA	1	25.5	7.1-79.9	0.67
SA	2	0	-	-
SA	3	0	-	-
SA	closed	-	-	-
GOM	1	0	-	-
GOM	2	0	-	-
GOM	3	0	-	-
GOM	closed	-	-	-
Sum stratified		25.5	7.1-79.9	0.67
Analyzed by hook				
SA	1	39.2	7.7-200.6	1.00
SA	2	0	-	-
SA	3	0	-	-
SA	closed	-	-	-
GOM	1	0	-	-
GOM	2	0	-	-
GOM	3	0	-	-
GOM	closed	-	-	-
Sum stratified		39.2	7.7-200.6	1.00

Table 5. Estimated takes (dead, alive, and other conditions) of loggerhead sea turtles for 2006 in the commercial directed shark bottom longline fishery.

Area	Season	Takes	95% CI	CV
Analyzed by set				
SA	1	38.2	13.3-95.9	0.54
SA	2	29.7	5.3-116.1	0.94
SA	3	0	-	-
SA	closed	-	-	-
GOM	1	0	-	-
GOM	2	0	-	-
GOM	3	39.1	7.0-172.5	0.96
GOM	closed	-	-	-
Sum stratified		107.0	- [1]	- [1]
Analyzed by hook				
SA	1	36.6	8.9-149.8	0.82
SA	2	71.2	13.9-364.1	1.00
SA	3	0	-	-
SA	closed	-	-	-
GOM	1	0	-	-
GOM	2	0	-	-
GOM	3	55.4	10.8-283.4	1.00
GOM	Closed	-	-	-
Sum stratified		163.2	56.6-470.8	0.58

[1] not estimated

Appendix A: NMFS required supplementary 2006 sea turtle information from the Sea Turtle Life History HMS Database. The table is split and rows are identified by record number.

Record Number	Season	Species	Area	Capture Condition	Hook Type	Offset (degrees)	Bait	Bait Size (g)
1	1	Caretta caretta	SA	Comatose (not successfully resuscitated)	14/0 J	0	Shark	257 g
2	1	Caretta caretta	SA	Fresh Dead	20/0 C	0	Ray or shark	122 or 284
3	1	Caretta caretta	SA	Alive, injured	20/0 C	0	Ray or shark	122 or 284
4	2	Caretta caretta	SA	Comatose (not successfully resuscitated)	14/0 C	Unknown	Little tunny	77
5	3	Caretta caretta	GOM	Alive, injured	14/0 J	0	Eel	Unknown

Appendix A continued:

Record Number	Final Disposition	Hook Location	Hook Removed?	Entangled Capture?	Entangled Release?	Line Left (ft)	CL Est. (ft)	CCL (cm)	SCL N-N (cm)
1	Discarded marked dead/unresponsive carcass	Mouth, lower, tongue	Yes	No	No	0.0		75.5	Not available
2	Discarded unmarked dead/unresponsive carcass	Shoulder	No	No	No	4.0	2.0	Not available	Not available
3	Released alive	Tail	Yes	No	No	0.0	4.0	Not available	Not available
4	Discarded marked dead/unresponsive carcass	Beak (internal)/mouth, unknown	Yes	No	No	0.0		78.8	Not available
5	Released alive	Front flipper/shoulder/armpit	Yes	No	No	0.0	4.5	Not available	Not available