SEDAR 58 Stock Assessment Report: Atlantic Cobia

SEDAR 58 Discard Mortality Ad-Hoc Group Working Paper

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NCDMF Onboard Observer Monitoring

Provided by Anne Markwith, NCDMF

Program Description and Methods

NCDMF's Program 466 (Onboard Observer Monitoring) was designed to monitor fisheries for protected species interactions in the inshore gill net fishery by providing onboard observations. Additionally, this program monitors finfish bycatch and characterizes effort in the fishery. Data recorded include species, weight, length, fate (landed, live discard, or dead discard), as well as gear parameters (mesh size, twine size, yardage). The onboard observer program requires the observer to ride onboard the commercial fishermen's vessel and record detailed gill net catch, bycatch, and discard information for all species encountered. Observers contact licensed commercial gill net fishermen holding an Estuarine Gill Net Permit (EGNP) throughout the state to coordinate observed fishing trips. Observers may also observe fishing trips from NCDMF vessels under Program 467 (Alternative Platform Observer Program), but these data are not presented due to the lack of biological data collected through the program.

Gill net fishing trips are observed throughout the year. However, cobia were only observed on trips that occurred May through October; the majority were observed in September. Trips with observed cobia accounted for 0.88% of all trips in 2004-2017. Cobia are considered incidental catch in the inshore gill net fishery, and a total of 71 cobia, 68 with known disposition, were caught from 2004-2017 (Table 1). Large mesh gill nets (>4-5 inches stretched mesh) account for 76% of the cobia observed, while small mesh gill nets accounted for 24% of the observed cobia. The majority of the fish were released; only four were kept. Of the fish released, 45% were dead. All discards were regulatory for the observed trips; cobia ranged in size from 128 mm (in 2008) to 780 mm FL (in 2004), with an average length of 416 mm FL (Table 2).

Potential Biases & Uncertainties

Program 466 began sampling statewide in May 2010. To provide optimal coverage throughout the state, management units were created to maintain proper coverage of the fisheries. Management units were delineated based on four primary factors: (1) similarity of fisheries and management, (2) extent of known protected species interactions in commercial gill net fisheries, (3) unit size, and (4) the ability of the NCDMF to monitor fishing effort. Total effort for each management unit can vary annually based on fishery closures due to protected species interactions or other regulatory actions. Therefore, the number of trips and effort sampled each year by management unit varies both spatially and temporally.

Program 466 data do not span the entire time series for the assessment and spatially limited data are available from 2000–2003 specific to the Pamlico Sound region and expanded effort since 2004 outside of the Pamlico Sound; however, observed trips were sparse and variable throughout 2004–2010 due to funding. Statewide sampling began in May 2010 decreasing the variability of observed trips with better spatial and temporal sampling beginning in 2012.

The sample size of cobia is small (n < 10 fish/year), and for several years less than five fish were observed in Program 466. In 2010, no cobia were observed.

Table 1. Summary of the number of observed inshore gill-net trips by NCDMF Program 466, 2004-2017, with cobia and the disposition of the fish including total number caught, kept, and released.

Year	Total observed trips	Total observed trips with cobia	Number kept	Total released alive	Total released dead	Total released with undetermined disposition	Total released	Total caught with recorded disposition	Total caught
2004	503	3	0	1	1	2	4	4	4
2005	441	5	0	1	5	0	6	6	6
2006	400	3	0	0	1	1	2	2	3
2007	130	1	0	1	0	0	1	1	1
2008	263	7	0	7	1	0	8	8	8
2009	234	6	0	2	2	0	4	4	6
2010	215	0	0	0	0	0	0	0	0
2011	465	3	0	1	2	0	3	3	3
2012	605	9	2	4	2	1	7	9	9
2013	656	5	0	5	3	0	8	8	8
2014	821	2	0	2	0	0	2	2	2
2015	778	3	1	1	4	0	5	6	6
2016	651	6	0	5	1	0	6	6	6
2017	740	8	1	3	5	0	8	9	9
Total	**6902**	**61**	**4**	**33**	**27**	**4**	**64**	**68**	**71**

Table 2. Lengths (fork length, mm) of released cobia from the observed inshore gill-net trips by NCDMF Program 466, 2004-2017.

Year	Total number released	Minimum (mm)	Maximum (mm)	Mean (mm)
2004	4	383	780	622
2005	6	254	580	348
2006	2	442	530	486
2007	1	-	-	579
2008	8	128	591	336
2009	4	322	551	464
2010	0	-	-	-
2011	3	296	530	437
2012	9	289	691	468
2013	8	221	718	443
2014	2	290	350	320
2015	6	390	410	400
2016	6	291	551	409
2017	9	178	433	336
Overall	**68**	**128**	**780**	**417**

Cobia Broodstock Collection Program, South Carolina Department of Natural Resources

Provided by Matt Perkinson, SCDNR

Program Description and Methods

The South Carolina Department of Natural Resources began aquaculture work with captive cobia in 2001, initially developing techniques for food fish production and transitioning into stock enhancement efforts to supplement the distinct population segment found in the St. Helena, Port Royal, and Calibogue sound estuaries. While broodstock collection efforts for this program were not designed as a method for estimating the mortality associated with hook and line efforts, detailed records of captive fish disposition are available from 2006-present date and may provide useful data on handling mortality. In particular, program methods allow researchers to observe captured cobia and evaluate outcomes in the days, weeks, and months following capture.

Cobia were targeted via hook and line using methods that are mostly reflective of the fishery at large (i.e., live, dead, and artificial baits fished opportunistically throughout the water column). When possible, large (5/0-8/0) circle hooks were used to minimize gut hooking and maximize hooking effectiveness. Cobia were collected via staff on a boat equipped with a 750-liter holding tank filled with local seawater and supplemented with oxygen diffusers. Each fish was captured via landing net or lip-gripping tool, the hook was removed, and the fish was transferred to the holding tank. In some instances, cooperating anglers provided captured fish as donations, in which case the fish were landed via net and passed to the staff boat before the hook was removed and the fish was placed in the holding tank. If the fish was hooked deeply, the line was clipped as close to the hook eye as possible. Following capture, any collected fish were brought back to a boat landing, transferred to an oxygenated fish hauling trailer, and transported to either the Waddell Mariculture Center in Bluffton, SC or the Marine Resources Research Institute in Charleston, SC. There, each fish underwent a five minute prophylactic dip in dechlorinated and pH-buffered freshwater to remove external parasites and was transferred to a 12,000-liter recirculating aquaculture system.

Since 2006, when detailed records are available, a total of 87 cobia have been collected and brought into recirculating aquaculture systems as broodstock. Of those 87, only one mortality occurred in the week following capture. That fish died of unknown causes on day seven following capture and no other cobia died within two weeks of capture.

Potential Biases and Uncertainties

While the program provides detailed records on the survival of cobia following capture, there are several caveats to keep in mind when evaluating the data source. Cobia were captured during this study by trained biologists or under the supervision of biologists with incentives for carefully handling and minimizing the mortality of captured fish. Landing nets or lip-gripping tools were used in all cases (as opposed to gaffs). Following capture, the fish were held in predator-free recirculating aquaculture systems. Alternately, cobia captured as part of this program were handled and transferred multiple times and often held in the onboard holding tank for 4+ hours before being moved into a larger tank, potentially resulting in greater handling stress than a typical fishing encounter may create. These caveats will need to be weighed carefully before using the data as a proxy for release mortality.

Cobia Acoustic Telemetry Study-Virginia, North Carolina, South Carolina, Georgia, and Florida

Provided by Matt Perkinson, SCDNR

Field Methods

Cobia from South Carolina, Georgia, and Florida were captured aboard paid charter vessels as part of a NOAA Cooperative Research Program-funded study to evaluate cobia migratory patterns in the Southeast United States. All fish were captured via hook and line using gear and tactics similar to those found in the recreational fishery (i.e., live baits and artificial lures fished opportunistically throughout the water column). Fish were captured via landing net and moved with a lip gripping tool, ventral side up, to a modified v-board placed in a cooler filled with recirculating seawater. A small incision, approximately 20 to 25 mm long, was made adjacent to the midventral line between the pelvic girdle and vent to insert a Vemco V16-4H (nominal life span=1,910 days) or V16-6H (nominal life span=3,650 days) acoustic transmitter. The incision was then closed with 1-2 interrupted sutures. These methods typically allowed for quick recovery and robust condition at the point of release. Following the surgical procedure, cobia were fitted with two nylon dart tags inserted into the dorsal pterygiophores to alert anglers to the presence of the internal transmitter and to ask them to release the cobia upon capture. A small 10x10 mm sample of tissue was taken from the anal fin of each fish for genetic analysis. Cobia were then transferred to the water, revived until able to swim off under their own power, and released. Most surgical procedures were completed in 5-10 minutes. Detailed methods are available in SD58-RD22. Cobia released in North Carolina and Virginia followed similar surgical procedures, but were tagged with $100 high-reward dart tags, and Virginia cobia had an additional archival tag inserted in the stomach cavity. North Carolina cobia were released as part of the cobia tagging program of the North Carolina Division of Marine Fisheries (NCDMF). Virginia cobia were released by North Carolina State University (NCSU) in collaboration with Virginia Institute of Marine Sciences (VIMS) as part of a North Carolina Coastal Fishing License Fund grant evaluating cobia migratory and survival in North Carolina and Virginia.

Table 3. Number and mean fork length (FL) of cobia tagged with acoustic transmitters (Vemco) by state during 2014-2018.

State	Number Tagged	Mean FL (mm)
Florida	74	835
Georgia	21	887
South Carolina	53	884
North Carolina	5	1003
Virginia	20	942
Total	**173**	**874**

Although the study was designed to evaluate cobia movement patterns, it may provide data on release mortality as well. Henceforth, release mortality for acoustically-tagged cobia is defined as surgery and hook-and-line mortality combined. Fish that were acoustically-tagged and were later detected on an acoustic receiver away from the release location were deemed to have survived the catch and release process. The possibility exists that a cobia could die following release and be predated upon by a shark, potentially resulting in spurious detection data. Based on the results of a current release mortality study of blacktip sharks using acoustic and satellite telemetry, it takes roughly 3-4 days for a shark to expel an acoustic tag following predation of a tagged animal (Bryan Frazier, SCDNR, personal communication). Therefore, cobia that were only detected within 4 days of release were removed from the group that was deemed to have survived. A total of 173 cobia were tagged and released from December 2014 to March 2019, of which 14 were harvested, 3 were caught-and-released, and 4 fish died near receivers (i.e. detected multiple months at the sight of release location). A total of 157 cobia were detected alive or recaptured following release. Of these, 6 were only detected within the 4-day window, although 1 of these was later recaptured by an angler. Therefore, we are confident that at least 152/173 (87.8%) survived the tagging process. The Cormack-Jolly-Seber Model detailed below provides a more quantitative means for estimating post-release mortality based on acoustic detection data.

Cormack-Jolly-Seber Model

Provided by Jacob Krause and Jeffrey Buckel, NCSU

Cormack-Jolly Seber Model with release mortality

Detections were collapsed into a capture history matrix with rows for individual fish and columns for months. The matrix contained a 2 when no detections occurred in a particular month and a 1 if there were one or more detections. As cobia had a staggered entry into the model, time periods when a fish was not yet released received a 0. All fish were assumed alive at release, and received a 1 in the month of their release. Cobia that were never detected after release received a 1 in their release month and subsequent months a 2. Cobia that immediately died within receiver range received a 1 in their release month and all subsequent months were changed from 1 to 2, as all detections need to be from live fish. Time periods after a fish was harvested received an NA. For fish that were caught by recreational anglers and released, they were given a 1 in that time period and a 2 for all subsequent periods. For harvested fish, they received 1 in the time period and NA for all subsequent periods.

Capture histories were analyzed using a modified Cormack-Jolly-Seber (CJS) model. We implemented the model using a Bayesian multistate modeling framework through OpenBUGS software in R. The basic CJS model is an open capture-recapture model that provides estimates of detection probability (probability that a live fish will detected on one or more receivers) and survival. The CJS model provides estimates of apparent (or “local”) survival—that is a fish’s probability of surviving and being in the study area (in this instance, the areas covered by receivers in the southeast U.S.). The modification was to estimate delta, the additional instantaneous mortality due to release mortality.

Individual survival across each monthly time period was estimated using

$S_{i,t} = \exp(-Z_t - \text{Z\_index}_{i,t} * \text{delta})$ (Equation 1) where $S_{i,t}$ is the discrete survival for fish *i* at time *t*, Z_t is the total instantaneous mortality at time *t*, delta is the instantaneous mortality due to capture and surgery, and Z_index $_{i,t}$ is a multiplier that only estimates delta for the time period immediately after release and is defined by the following

Z_index $_{i,t}$ = step((f_i+ProbLength-1)-$_t$) (Equation 2)

where Z_index $_{i,t}$ is a matrix of 0 and 1s created by the step function in OpenBUGS. The function works in the following manner: V is any node, where step(V) equals 1 if $V \geq 0$ and equal to 0 if V<0. For our model in the step function, f_i is the time period when fish enter the model (e.g. month of fish release). The ProbLength is the number of periods or months when release mortality applies, or when delta should be estimated for an individual fish. For our model, ProbLength=1 time period which is equal to the number of days between release and the end of the month (<31 days). A 1 is subtracted because survival estimates are always 1 less than the number of periods and time *t* is the monthly period in the matrix. For example, if a fish is released in month 3, f_i = 3, and the ProbLength is always 1. The step function would assign a 1 in the Z_index $_{i,t}$ matrix for this fish at time 3 because the equation equals 0. In contrast, at time 4 the function would assign 0. In equation 1, the delta term is not estimated when the particular cell in the Z_index $_{i,t}$ matrix is 0, and vice versa. The model used an uninformative uniform (0 to 2) prior for delta and Z_t.

Results

Monthly capture histories were constructed for 173 cobia based on daily detections (Fig. 1), resulting in 52 monthly periods. A total of 157 out of 173 fish were detected on passive arrays following release or caught by anglers (Fig. 1). The capture histories of 21 fish were altered by adding detections when a fish was alive by anglers (i.e. date of harvest or catch-and-release) or remove detections for fish that were detected “dead” at the release site.

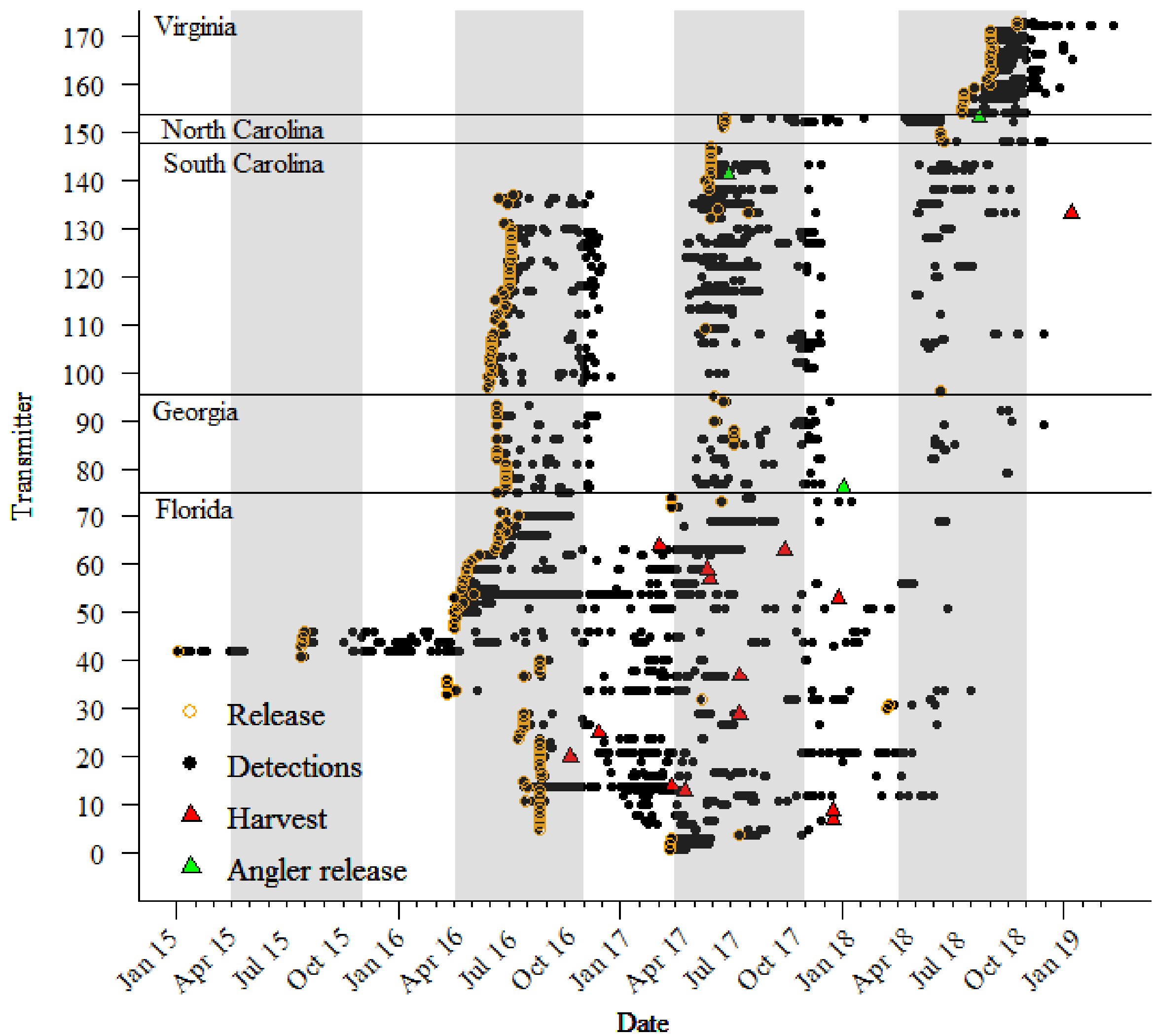

Fig. 1-Abacus plot of cobia detections by the state of release with harvests and recreational catch and release events from December 15, 2014 to March 7, 2019. The gray shaded portions are 6-month periods from May to November.

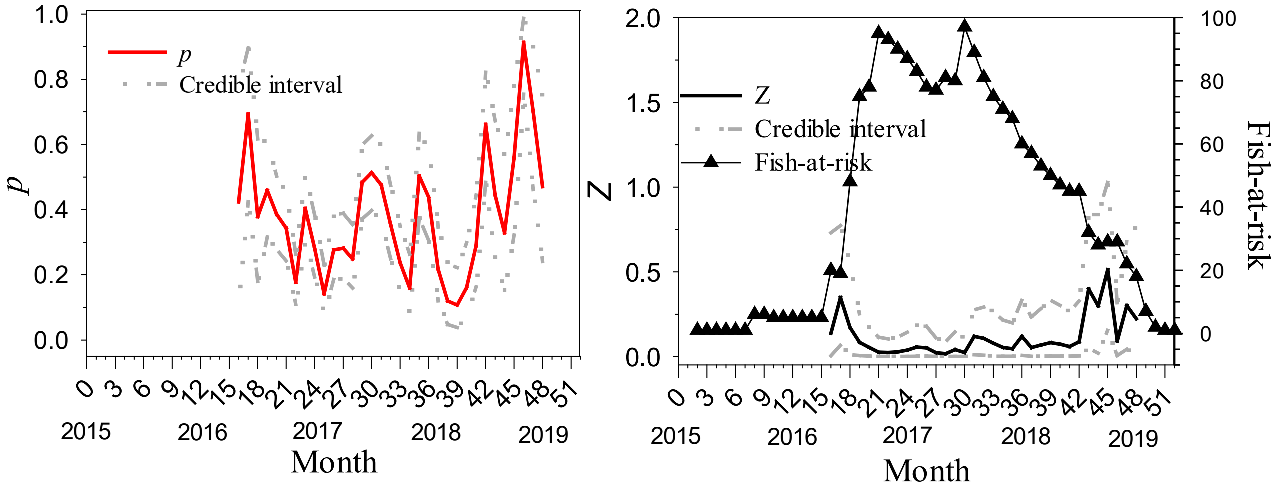

Fig. 2-a) The detection probabilities (*p*) and the b) instantaneous total mortality (*Z*) with credible intervals from 2015 to early-2019. Estimates were only shown when at least 10 fish were at-risk within the model or the number of fish the model estimates as alive.

Estimates with less than 10 fish at-risk were not shown, as the low sample size estimates parameters with such wide credible intervals to be biologically meaningless. The median detection probability ranged between 0.11 and 0.91 and averaged 0.38 across all time periods when at least 10 fish were at-risk. Upward spikes in detections tended to be during spring and fall migration time periods when fish are migrating and have high probability of being detected on coastal telemetry arrays (Fig. 2a, Fig.1). The instantaneous apparent total mortality (*Z*) ranged from 0.017 to 0.51 with the average across the periods when at least 10 fish were at-risk was 0.12. The *Z* credible intervals narrowed when the number of fish-at-risk increased in the model, but was highest at the beginning and end periods (Fig. 2b).

Delta, or the instantaneous release mortality due to fishing and surgery was estimated as 0.046 with the 95% credible intervals ranging from 0.003 to 0.133.

Discussion

The model allows for a method to estimate release mortality with uncertainty. The parameter delta estimates both discard and surgery mortality. The current model framework allows for flexibility to update model estimates with the inclusion of new telemetered fish or detections, allowing for more precise estimates. New fish should only be added when ample time has passed for fish to pass multiple receiver arrays (e.g. spring and fall migration) and for researchers to send detections after downloads. For our model, all fish had at least 6 months of time to be detected.

Potential Biases and Uncertainties

The acoustic telemetry study provides some of the only available data on the behavior of cobia following catch and release and has a relatively robust sample size (n=173). However, the data comes with many caveats and potentially should be considered as an upper bound on release mortality. While a cobia that is tagged, released, and then later detected in multiple locations over several years clearly survived the process, a lack of detections from a tagged fish does not mean that the fish did not survive*. Acoustic receiver coverage, while increasing, is relatively sparse in relation to the amount of open ocean and is not homogeneously deployed. Fish tagged in areas with less dense coverage may be less likely to be later detected and detection data are not always downloaded and shared in a timely manner. Therefore, additional detections may exist for some of the fish that have not been detected to date. Tagged cobia may have also been harvested by anglers without being reported. Finally, while the cobia in this study were landed by trained scientists using nets (as opposed to a gaff), the additional handling and invasive nature of the surgical procedure may contribute to greater overall mortality. Evaluating cobia mortality by these methods may result in an overestimate of release mortality due to the caveats described above. However, the data may provide an upper bound for release mortality and have therefore been submitted for consideration.

**Note-the CJS model accounts for detection probability and may have less potential to overestimate mortality.*

SCDNR Charterboat Logbook Program Data, 1993 – Current

Provided by Amy Dukes, SCDNR

Program Description and Methods

The South Carolina Department of Natural Resources (SCDNR) issues a charter vessel license to vessels carrying six or fewer passengers. In 1993, SCDNR's Marine Resources Division (MRD) initiated a mandatory logbook reporting system for all charter vessels to collect catch and effort data. Under state law, vessel owners/operators purchasing a South Carolina Charter Vessel License and carrying fishermen on a for-hire basis are required to submit trip level reports of their fishing activity in waters off of SC. Logbook reports are submitted in person, by mail, fax, email (scanned reports), and most recently (January 2016), through an electronic application to the SCDNR Fisheries Statistics Section monthly. Reporting compliance is tracked by staff, and charter vessel owners/operators failing to submit reports can be charged with a misdemeanor. The charterboat logbook program is a complete census, and should theoretically represent the total catch and effort of all charterboat trips in waters off of SC.

The charterboat logbook reports include: date, number of fishermen, fishing locale (inshore, 0-3 miles, >3 miles), fishing location (based on a 10x10 mile grid map), fishing method, hours fished, target species, and catch (number of landed and released fish by species) per vessel per trip. The logbook forms have remained similar throughout the program's existence, with a few exceptions: in 1999 the logbook forms were altered to begin collecting the number of fish released alive and the number of fish released dead (prior to 1999 only the total numbers of fish released were recorded) and in 2008 additional fishing methods were added to the logbook forms, including cast, cast and bottom, and gig.

After being tracked for compliance, each charterboat logbook report is coded and entered into an existing Access database. Since the inception of the program, a variety of staff have coded the charterboat logbook data. From 1993 to 2006, only information that was explicitly filled out by the charterboat owners/operators on the logbook forms was coded and entered into the database. No efforts were made to fill in incomplete reports. From 2007 to the present, staff have attempted to fill in incomplete trip reports through conversations with charterboat owners/operators and by making deductions based on context clues from the provided data (i.e. if a location description was given instead of a grid location – a grid location was determined, if fishing method was left blank – it was determined based on catch, etc.). From 1999 to 2006, each individual trip record was reviewed for anomalies in the data. Starting in 2007, queries were used to look for and correct anomalous data, and staff began checking a component of the database records against the raw logbook reports. Coding and QA/QC measures prior to 1999 were likely similar to those used from 1999 to the present. However, details on these procedures are not available since staff members working on this project prior to 1998 are no longer with the Agency. Data are not validated in the field, and currently no correction factors are used to account for reporting errors. Recall periods for logbook records are typically one month or less. However, in the case of delinquent reports, recall periods could be up to several months. The initiation of the electronic application in January 2016 has increased the reporting periodicity (reduced recall basis) as more license holders are transitioning to reporting electronically (>65%), and with less time between for-hire trips taken and submitted reports.

Table 4. South Carolina cobia data collected from charter logbook program, 1993-2017. Highlighted cell in 2009 indicates high number of estimated dead discards that cannot be verified by original records.

Year	Total Charter Trips	Number Kept	Lbs Landed	Number Released Alive	Number Released Dead	Total Released	Total Caught
1993	4843	152	4800	99		99	251
1994	5696	150	4427	58		58	208
1995	5683	94	3186	24		24	118
1996	5901	114	3708	50		50	164
1997	6231	86	2541	141		141	227
1998	7791	208	5777	640		640	848
1999	7979	544	15420	571		571	1115
2000	9115	336	10043	434	2	436	772
2001	8846	482	14863	550	1	551	1033
2002	8837	379	12903	361	2	363	742
2003	8563	410	13362	243	5	248	658
2004	8546	472	15497	309		309	781
2005	9100	465	15490	303	1	304	769

2006	8913	247	7657	714	1	715	962
2007	9474	514	15085	829	1	830	1344
2008	8927	480	15428	503		503	983
2009	9227	438	13035	437	49	486	924
2010	10482	444	11950	477	3	480	924
2011	11108	281	8418	397		397	678
2012	12231	500	15255.5	465	2	467	967
2013	12962	505	15638	530		530	1035
2014	13702	419	14024	398	2	400	819
2015	15609	485	14458	564		564	1049
2016	14361	250	8110.6	380	0	380	630
2017	15501	0	0	588	1	589	589

Potential Biases and Uncertainties

The logbook program collects information on the number of cobia harvested, released alive, or released dead by charter anglers. The data is self-reported and does not provide information on the ultimate fate of cobia following release. Additionally, the number of dead discards reported in 2009 is substantially larger than all other years and cannot be verified by original paper logbooks.

Use of Pop-Up Satellite Archival Tags (PSATs) to Investigate the Movements, Habitat Utilization, and Post-Release Survival of Cobia (Rachycentron canadum) that Summer in Virginia Waters (from S58-SID02, Jensen and Graves).

Program Description and Methods

This study used three models of pop-up satellite archival tags (PSATs) to assess cobia movements, habitat utilization, and post-release survival following capture in the recreational fishery. All angling and tagging was completed within the Chesapeake Bay and surrounding coastal Virginia waters. Fish tagged for this study are representative of the size classes targeted by recreational fishermen (greater than 37 inches total length).

Cobia for this study were caught by recreational anglers, both private and charter, using methods of their choice which are assumed to be representative of typical recreational practices. The most common methods of fishing for cobia were chumming or sight-casting using live or artificial baits rigged with J-hooks, or lures rigged with J-hooks. Fish were hooked, landed, netted, and brought into the boat for measurement and tag attachment. Data recorded for each fish included total length in inches, estimated weight in pounds, fight time, air exposure time, bait, hook type, release location, and any observational notes. Tags were attached to fish using standard methods developed by Graves et al. (2002). Each PSAT was tethered to an intramuscular anchor that was inserted into the fish musculature below the posterior dorsal fin and well above the coelomic cavity, ideally with the dart interlocking with the pterygiophores. Each specimen was released as quickly as possible. The tether linking the intramuscular anchor to the PSAT was 80-pound test monofilament line secured with stainless steel crimps; total tether length was approximately 16 centimeters.

Tagged cobia were considered to have survived capture and release if the tag collected data indicating specimen activity for at least ten days after release. The ten-day duration was selected as a time period short enough to minimize observations of natural mortality but long enough to detect mortality resulting from capture events. It is usually impossible to distinguish natural mortalities from catch-related mortalities that occur several days after release, so this study assumed that any mortality occurring within 10 days of release as fishing mortality (resulting from the processes of capture, tagging, and release). A deceased fish will sink to the ocean floor, so mortality should be indicated by a drop in measured water temperature, constant depth below the surface (in the case of MTI pressure-sensing tags) or a nearly vertical tag (in the case of WC tags with an inclinometer). All cobia above the minimum size limit were tagged regardless of condition.

Results

A total of 36 cobia were tagged, 8 of which were deeply hooked. From the 36 successfully tagged cobia, only 24 tagged cobia reported usable data and only 20 tags remained on Cobia for at least 10 days. The 20 tagged cobia had data that were consistent with survival, which included 7 out of the 8 fish that were deeply hooked (i.e., no direct evidence of mortality events).

Potential Biases and Uncertainties

The workgroup had concerns about additional handling time that occurs during the tagging process. Longer handling times may induce more stress on the fish than typically occurs during a hook and line fishery. The sample size of tags that remained on fish for at least 10 days and eventually deployed and transmitted data was also relatively small (n=20). However, of these 20, all were determined to have survived the capture, tagging, and release process.

Commercial Logbook Data (NOAA SEFSC)

To be added before the data workshop.

Gill Net Observer Program (NMFS)

To be added before the data workshop.