AN EXAMINATION OF RECREATIONAL ANGLING FOR SHARKS IN DELAWARE WATERS

by

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ABSTRACT

Recreational angling targeting prohibited shark species (e.g. Sand Tiger (*Carcharias taurus*) and Sandbar (*Carcharhinus plumbeus*) Sharks) has increased in Delaware, raising concerns about the population status of these species. In an attempt to help address these concerns, my thesis had two objectives: to better understand recreational anglers' perceptions of and interactions with prohibited sharks; and to explore gear modifications that result in minimizing harm to shark species caught during recreational angling. To achieve my first objective, I developed an angler survey with the goals of: 1) improving our understanding of threats to sharks, 2) identifying potential solutions to threats of shark conservation, and 3) improving fisheries management of sharks through reduced injury or mortality. The survey highlighted the need for improved accuracy in species identification and compliancy with best angling practices and/or regulations as threats to shark conservation. My findings suggest that resource managers may modify their approaches to reduce injury or mortality of sharks through increased angler education and training, K-12 education, social media campaigns, and increased enforcement. Building upon this, I examined the efficacy of experimental (blocker) longline gangions compared to control gangions for reducing damage to individual Sand Tiger and Sandbar Sharks during capture events. Over a three year period (2012-2014) comprising of 153 longline sets, I landed 493 Sand Tiger and 240 Sandbar Sharks. Overall catch rates of Sand Tigers (T-test, $p = 0.024$) and Sandbar Sharks (T-test, $p = 0.013$) were reduced on the

experimental gangions. Gear type had a marked impact on hooking location ($p = 0.003$) for Sand Tigers as the overwhelming majority (96.3%) of gut hooked Sand Tiger individuals were encountered on control gangions. The use of blocker gangions shows much promise in minimizing risk of injury for Sand Tigers captured during longline surveys. In the case of Sandbar Sharks, there were no incidents of gut hooking in the entire study suggesting that the risk of injury from gut hooking is minimal for the species. The marked decline in gut hooking rates with Sand Tigers noted with the use of the experimental gangions underscores its potential use as a tool to reduce injury risk and to improve post-release survival prospects. It is well understood that a healthy marine environment provides direct and indirect economic awards and healthy shark populations are a key point in these environments. I hope my efforts to provide insights on angling preferences and practices in Delaware, as well as a potential tool for use in the angling community, will help foster increased recovery prospects for these important species.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

UNDERSTANDING RECREATIONAL ANGLER PERSPECTIVES IN DELAWARE'S SHARK FISHERY

CHAPTER I: INTRODUCTION

There is a growing body of evidence suggesting that many sharks exhibit life-history traits (e.g. late maturation and low fecundity) that make them susceptible to overharvest (Powles et al. 2000; Kraska et al. 2015). Commercial fishing is often blamed for the fin (Clarke et al. 2006; Dulvy et al. 2008) and meat trade (Reifenberg 2016). There are numerous studies which note the harmful effects of overfishing, as sharks play significant roles in structuring marine communities (Heithaus et al. 2008; Ruppert et al. 2013; Shiffman and Hammerschlag 2014). The complex trophic effects resulting from the depletion of sharks are difficult to predict, but are likely to have ecological and economic impacts, and may exist for a long time (Barker and Schluessel 2005).

While often overshadowed by commercial fishing, there is evidence that recreational fisheries are a significant factor in the exploitation of marine fishes (Pauly et al. 2002; Cooke and Cowx 2004). It has been estimated that recreational anglers account for approximately 10 percent of total global landings, harvesting 47 million fishes annually (Coleman et al. 2004; Cooke and Cowx 2004). In the recreational sector, anglers not only target sharks, but they also land sharks as bycatch when targeting other species (Danylchuk et al. 2014). In global recreational fisheries, sharks have been highly prized since the mid-20th century, ultimately resulting in the sector being a significant source of mortality (Gallagher 2015). There is increased pressure for resource managers to consider recreational fisheries as a critical contributor to negative impacts on populations, specifically changing the structure and yield of global fish stocks (Cooke and Cowx 2004).

The sustainability of catch and release practices is reliant on the low post-release mortality of caught individuals (Cooke and Schramm 2007). Although catch and release is

commonly practiced, post release mortality and sublethal effects on growth and fitness are consequences of recreational angling (Cooke and Cowx 2004; Kilfoil 2014). Recently, it has been proposed that even low levels of mortality from recreational fisheries can significantly add to the imperiled status of sharks (Shiffman and Hammerschlag 2014; Kilfoil et al. 2017).

Recognizing the important role of anglers in conjunction with a general lack of baseline biological data for many species of large coastal sharks, the National Marine Fisheries Service (NMFS) established the Apex Predator Program. This program coordinates the mid-Atlantic and northeast Atlantic Coast segments of the Cooperative Shark Tagging Program and provides thousands of volunteer recreational anglers and commercial fishers with tags for use in population and movement studies (NMFS Northeast Fisheries Science Center 2018). Between 1962 and 2016, more than 290,000 sharks representing 52 species were tagged. Ideally, this program not only allows scientists to collect data, but creates a relationship between the anglers and fisheries scientists involved in management decisions. This relationship is intended to diffuse potentially tense situations when management decisions are made that would typically frustrate anglers. As this is a cooperative program with volunteers there is no training program per se, however the program's website (https://www.nefsc.noaa.gov/nefsc/Narragansett/sharks/tagging.html) has numerous instructions and diagrams for volunteers, including instructions for tagging sharks, how to maximize shark survivability, and a species identification guide. However, there is growing concern that some anglers misuse the program, target prohibited species, and improperly handle sharks (Kilfoil 2014). Such misuse could be detrimental to sharks and run counter to the program's goals. One critique of the program is that although shark tagging is important, there are not strict qualifications (i.e. no formal training for the inexperienced tagger) on who can obtain the NOAA

kit to tag sharks, thus individuals may be handling the sharks in a manner that is unlikely to result in high survivorship (Kilfoil 2014; Ferrar 2016). Anglers often post pictures of the sharks they caught and presumably tagged on social media sites, illustrating that these anglers treat the sharks in a manner counterproductive to a rapid release following capture (Fox et al. 2015). These specific types of actions are listed in the instructions for anglers wishing to tag sharks as improper handling of sharks; the instructions provide clear instruction for anglers to abstain from dragging sharks onto the sand, sitting on sharks, or holding the sharks' mouths open for pictures (NMFS 2013). Furthermore, a study with members of the shore-based angling community in Delaware, observed that a large percentage of the sharks caught by fishermen participating in this program were prohibited species (Kilfoil 2014). In fact, some anglers targeting Sandbar (*Carcharhinus plumbeus*) and Sand Tiger (*Carcharius taurus*) Sharks justified their continued angling by claiming that they were doing no harm, and in many cases, were assisting scientists through their participation in the Cooperative Shark Tagging Program (Kilfoil 2014; Fox et al. 2015).

Delaware is home to many species of sharks including Spiny Dogfish (*Squalus acanthias*) and Dusky Smooth-hound (*Mustelus canis*), as well as popular targeted species such as Common Thresher (*Alopias vulpinus*) and Shortfin Mako (*Lsurus oxyrinchus*) Sharks. Prohibited species including Dusky (*C. obscurus*), Sandbar, Sand Tiger, and White Sharks (*Carcharodon carcharias*) also inhabit these bodies of water (Delaware Department of Natural Resources and Environmental Control 2017). Increased targeting of coastal sharks including prohibited species may be due to declines in historically targeted species and advancements in fishing techniques (Kilfoil 2014). As an example, Sand Tigers likely gained popularity among anglers due to their large size, intimidating appearance, and ease of capture; in 2010, two charter

operations began actively targeting this species, and shore-based shark tournaments were held (Fox et al. 2015). Increased recreational angling pressure has resulted in increased physical damage and mortality risk for Sand Tigers (Kilfoil et al. 2017). To address this emerging fishery for prohibited sharks, Delaware implemented Regulation 7 DE Admin Code 3541 in 2011, which states "It is unlawful for any hook and line fisherman to remove from the water sandbar shark, or any other species of shark when prohibited from harvest" (6.0; Office of the Registrar of Regulations, Legislative Council, State of Delaware, 2015). Under this ruling, any prohibited species must be released with minimum harm with the aim of increasing post release survival in Delaware waters. Anecdotally, this regulation appears to have had some success in reducing stressful capture events, and in doing so, curbing the appeal of the recreational fishery by preventing anglers from dragging sharks onto the beach (Fox et al. 2015; Kilfoil et al. 2017).

Recreational anglers may have a previously undocumented role in contributing to the injury or mortality of imperiled species and there is a need to consider if this angling effort is detrimental to promoting the conservation of those species (Cooke et al. 2014). Interestingly, a study on the Florida recreational shark fishery proposed that anglers who engage in responsible catch and release fishing activities may represent overlooked conservation supporters through their understanding of species that are managed (Shiffman and Hammerschlag 2014). In Florida, most charter captains felt their clients most enjoyed the challenge of large sized catches with a goal to obtain a photograph. During a cooperative shore tagging study in Delaware, anglers who targeted sharks while surf fishing expressed the misconceptions that if the fish swims away, it is ok (Kilfoil 2014). If this misconception is shared among anglers, there may be a misunderstanding of shark conservation and a lack of awareness of potential lethal and sub-lethal consequences of capture.

Angler behavior can impact effort and outcomes on exploited or threatened species, and therefore, there is a need to include human dimensions in fisheries management to increase the likelihood of tangible conservation benefits (Mascia et al. 2003; Gallagher 2015). Furthermore, biological or ecological knowledge solely is not sufficient for protecting species given that human behaviors are usually associated with conservation problems and solutions (Fox et al. 2006).

When searching for processes others have used to gather information on angler thoughts and perceptions, I found that surveys are common and an effective method to determine angler perceptions (Gallagher 2015; New Jersey Department of Environmental Protection 2015; Slagle et al. 2015). With inputs from previous studies focused on the risk of injury or mortality facing prohibited sharks (Kilfoil 2014; Fox et al. 2015), I developed a survey to gauge Delaware's recreational angler perceptions, motivations, and practices of shark fishing. The angler survey had goals of: 1) improving our understanding of threats to sharks, 2) identifying potential solutions to threats of shark conservation, and 3) improving fisheries management of sharks through reduced injury or mortality. In the end, I hoped to provide an improved understanding of angler attitudes thereby increasing the likelihood of successful conservation and recovery of these prohibited species (e.g. Sandbar Sharks and Sand Tigers). Ultimately, I hope that the angler perceptions and motivations revealed as results of my survey will be used to reduce direct targeting of prohibited sharks by facilitating education and outreach programs (Kilfoil et al. 2017).

CHAPTER I: METHODS

Survey Formatting and Administration

My survey was developed through a collaborative process that underwent multiple reviews. Additionally, to establish content validity (i.e. confirmation that the survey measures the correct subject and that appropriate questions are being asked) (Drost 2012), the survey received input by state and federal fishery agencies. In developing the survey, I grouped questions by order and type into constructs as a method of identifying similar behaviors to communicate results (Fanning 2005) (Table 1-1). As a final step, the survey was approved by the Delaware State University Human Subjects Research Office.

My 22-question survey was intended to assess the following: respondent demographics (n=3), fishing preferences (n=4), angler shark interactions (n=5), conservation knowledge (n=5), and shark management strategies (n=5). Potential respondents were drawn from 26,459 individuals who were in possession of a Delaware Department of Natural Resources and Environmental Control (DNREC) Division of Fish and Wildlife tidal or ocean recreational finfish license from March to September 2016. The survey was administered through a public link (via https://www.surveymonkey.com) that respondents could access and share freely. On November 7, 2016, the survey link was emailed to a randomly selected sub-sample of 1,500 anglers by DNREC. In an effort to capture experienced anglers who were knowledgeable about local issues related to sharks and shark fishing, on November 8 and 9, 2016 the survey was posted on regional fishing forums (https://delaware-surf-fishing.com/ and https://saltfish.vbulletin.net/). On December 1, 2016 DNREC randomly selected another 1,500 individuals without replacement to bolster sample sizes. The survey was closed on December 19, 2016. In this case, I used convenience sampling, specifically snowball and chain-referral,

where individuals in a targeted community suggest or pass-along the survey to subsequent users (Penrod et al. 2003). This survey methodology has been widely used in the social sciences as well as in the fisheries literature (e.g., Hasler et al. 2011; Cooke et al. 2012), and is well-suited to obtaining valuable responses on potentially sensitive issues from informed and experienced users (Gallagher 2015). Chain-referral internet surveys have several advantages over conventional survey designs but also have important limitations, particularly the nonrandom sampling-based survey design prevents generalized insights for all saltwater anglers (Gallagher 2015). This method may fail to reach those in the angling community who are not internet users, well informed, or especially skilled (Gallagher et al. 2016).

Analyses

Margin of error was calculated for each question as follows, (Equation 1) where $\hat{p}$ is the sample proportion (the number of respondents to each question), n is the sample size (3,000), and z* is the appropriate z*-value (1.96) for a 95% confidence interval

$$z * \sqrt{\frac{\hat{p}\,(1-\hat{p})}{n}} \qquad \text{Equation 1}$$

Respondent demographics were considered in relationship with fishing preferences and angler-shark interactions. Mode of fishing was examined in relationship to each prohibited species of shark that respondents reported catching. Respondents were allowed to choose more than one option when selecting what shark specific actions they take when fishing, therefore reported results may not equal 100%. For the Likert-item (Brown 2011) questions (offering a series of answer options ranging from one extreme to another) (Table 1-2), I reported the percentage of respondents who agreed or disagreed for each question.

Rankings are presented with the management option and the percentage of respondents that chose that option as the most common choice for each ranking level (e.g. first, second, etc.)

and some options were chosen for multiple ranking levels. To quantify the rank order of management options anglers would be willing to adopt, http://www.surveymokey.com calculated the weighted averages of the rankings. Weights are applied in reverse; the answer choice with the largest average ranking is the most preferred choice and their least preferred choice has a weight of one. The average ranking is calculated as follows (Equation 2), where:

w = weight of ranked position and x = response count for answer choice

$$\frac{x_1w_1+x_2w_2+x_3w_3+x_4w_4+x_5w_5+x_6w_6}{\text{Total}} \qquad \text{Equation 2}$$

I employed a binomial logistic regression to model what factors affect the thought that current management measures and restrictions conserve sharks (Brinson and Wallmo 2017). The Likert statements that were used in the model are as follows: "If I catch a shark, I am confident I will be able to identify it"; "I am comfortable with handling sharks"; "Anglers present no harm to sharks when fishing"; and "I believe prohibited sharks need to be protected." The responses to the Likert questions were coded as follows: "Somewhat disagree" and "Strongly disagree" =0; and "Prohibition," "Risk," "Comfort," and "Identification" =1. The independent variables (demographic information and behavioral characteristics) were as follows: "Age"; "Avidity" (years fishing/fishing experience); "Hours spent fishing from a charter or head boat"; "Hours spent fishing from private boat"; and "Hours spent fishing from the shore". I transformed responses that included years in range form to be the average of the range. The question, "will current management measures and restrictions conserve sharks?" was the dependent variable. Respondents were asked to choose if they believed that current management or restrictions in Delaware would conserve sharks, coded as "Yes"=1, "No"=0, and blank=9. The belief that current management will conserve sharks was modeled as a function of respondent age, avidity (years fishing/fishing experience), hours fishing from charter or head boat, hours fishing from

private boat, hours fishing from the shore, comfort with handling sharks, risk of injury to sharks, protection for prohibited sharks, and shark identification (Brinson and Wallmo 2017). A binomial logistic regression can be estimated (Equation 3), where

$$\Pr[y_i = 1] = \pi_i = \frac{\exp^{zi}}{1 + \exp^{zi}} \qquad \text{Equation 3}$$

$y_i = 1$ indicates that anglers believe current management will conserve sharks

$z_i = B_o + B_{avidity} + B_{age} + B_{residence} + B_{years\ fishing} + B_{identification} + B_{comfort} + B_{angler\ risk} + B_{prohibition}$

The coefficients are measures of the rate of change in the satisfaction log odds, in this case the likelihood that an angler believes current management measures and restrictions will conserve sharks. Positive signs on a coefficient indicate that a unit increase in the likelihood of satisfaction and a negative sign on a coefficient has the opposite effect. Factors that influenced the belief that current management measures and restrictions will conserve sharks will have a positive coefficient with significance $p \leq 0.05$. These statistical analyses were performed with Stata 14.2 (Stata Corp 2015).

CHAPTER I: RESULTS

DNREC contacted 3,000 registered tidal or marine anglers; the survey was viewed on the Delaware Surf Fishing Facebook, https://www.delaware-surf-fishing.com, and https://www.saltfish.net. The survey was open from November 7 until December 19, 2016 during which time 363 individuals consented to take the survey, 7 refused to consent, and 226 completed the survey. There were no repeated IP addresses from the respondents, so I assumed that individuals did not repeat the survey. For the purposes of reporting results, the sample size represents all individuals who responded (n=226) unless otherwise specified; the margin of error (ME) for all questions was 6% unless otherwise stated. There were 125 Delaware respondents

and 101 out-of-state respondents from PA (n=58), MD (n=25), VA (n=9), NJ (n=5), and NH, NY, D.C., WV (n=1, each). The respondents ranged in age from 17 to 81 (mean=45) and had between 2 and 78 (mean=35) years of fishing experience.

Fishing Preferences

Respondents were asked to choose all time periods that apply when fishing occurs, thus percentages exceed 100%. Out of 226 respondents, 70% fish in the morning (6am-12pm), 54% fish as time permits 53% fish in the afternoon (12pm-6pm), with a slight drop off in the evening (6pm-2am) when 47% go fishing. Anglers annually spend an average of 216 hours fishing; 12 hours fishing from a charter boat, 86 hours on private boat, and 118 hours from the surf (hereby referred to as the shore). On average, anglers spend 72 hours annually on catch and consume, 131 hours annually on catch and release, and 9 hours annually fishing for competition. The top three primarily targeted species identified by respondents were Striped Bass (*Morone saxatilis*) (87%), Summer Flounder (*Paralichthys denatatus*) (85%), and Bluefish (*Pomatomus saltatrix*) (77%); one respondent specified only targeting sharks (Figure 1-1).

Angler Shark Interactions

Approximately 41% of respondents (n=132, 8% margin of error) indicated they target sharks, spending an average of 68 hours annually doing so. Those who indicated targeting sharks spend nearly one quarter of their time on each fishing mode (i.e. private boat (n=157), charter boat (n=101), or the shore (n=186)). Of those who do target sharks, 78% fish in the morning, 54% as time permits, 52% in the afternoon, and 30% at night. The majority of anglers who target sharks use circle hooks (89%) and remove hook and gear (81%) from sharks that are caught.

Out of 226 respondents, anglers reported commonly catching Dusky Smooth-hounds (46%), Sandbar Sharks (45%), Spiny Dogfish (40%), Sand Tigers (27%), and Dusky Sharks

(16%). Other sharks that anglers specified commonly catching were Hammerhead (*Sphyrna spp.*) (n=4) and Spinner Sharks (*Carcharhinus brevipinna*) (n=2). Three (Sandbar, Sand Tiger, and Dusky Sharks) of the top five shark species respondents reported commonly catching are prohibited species; regardless of fishing mode, percentage of catches were greater for Sandbar Sharks than Sand Tiger and Dusky (Table 1-5). Anglers who catch these prohibited species reported removing hook and gear from sharks that are released (94%), using circle hooks (82%), and keeping the shark in the water upon release (76%).

The majority of anglers are comfortable with handling sharks (81%) and felt that recreational angling was a potential risk factor to prohibited sharks' conservation or could present harm to sharks (70%) (Table 1-2).When considering the shark specific actions anglers take when they fish, 54% reported keeping the shark in the water when releasing it, 50% remove the terminal tackle from sharks that are released, and 28% try to avoid sharks (Figure 1-2). Anglers also reported leaving the hook in place when releasing sharks (23%) and using J-hooks (8%). When considering conservation engineering techniques, 3% of anglers claimed to use blocker rigs (a length of plastic pipe mounted perpendicular to the leader a specific distance from the hook, preventing the shark from swallowing the bait). Respondents who reported using conservation engineering techniques are Delaware (n=4) and Maryland (n=3) residents. A majority (86%) of those who use blocker gangions fish from shore and less than half (47%) use circle hooks when fishing for sharks. Of those who claim to not do any of these actions when fishing (Figure 1-2), 36% (n=44) indicated that they do not catch sharks.

Conservation Knowledge

The majority (73%) of anglers claimed that they are confident in identifying a shark if they catch one. Respondents were asked to identify prohibited species from a pre-existing list

and only 16% of anglers were able to correctly identify those that commonly occur in Delaware; Dusky, Sandbar, Sand Tiger, and White Sharks. Most respondents are aware of minimum size restrictions (83%) and bag limits (81%) for sharks in Delaware. Of the provided answer choices, handling practices (81%), commercial fishers (73%), angler experience (65%), and hook type (62%) were identified as negatively contributing to the conservation of prohibited sharks (Figure 1-3).

Management Strategies

The overwhelming majority (84%) of respondents agreed that prohibited sharks need to be protected (Table 1-2). Due to an oversight in question design, there was some uncertainty by respondents (n=2) about the rank ordering of numerical scores suggesting these results should be taken with caution. Seasonal restriction was most frequently chosen (23%) as the number one management option anglers would be willing to adopt. Anglers were least likely (20%) to comply with a restriction on the means of bait deployment. Management options ranked from most to least willing to adopt are as follows (percentages represent the highest amount of respondents that chose the management option for the pertaining ranking level): seasonal restriction (first; 23%), size limit (second; 25%), seasonal restriction (third; 18%), area restriction (fourth; 23%), leader restriction and means of deployment (e.g. kayaking bait from the shore, chumming, etc.) (fifth; 19%), leader restriction (e.g. terminal tackle) (sixth; 19%), and means of deployment (seventh; 20%) (Table 1-3).

A slight majority (54%) of anglers were uncertain if current measures and restrictions will conserve sharks, while about out one third (30%) believe current management measures and restrictions will conserve sharks. Results of the binomial logistic regression (Table 1-4) were unable identify any factors that influenced anglers' belief that current management measures and

restrictions will conserve prohibited sharks ($p>\chi^2=0.905$). Anglers were also divided when asked if there should be more or fewer regulations in Delaware; 26% would like more, 23% would prefer less, and 50% were uncertain.

Less than half of respondents (41%, margin of error is 9%) offered input on how management can be changed to enhance shark conservation. Many of the suggestions focused on more education and training for anglers (40%), changes in current regulations or new regulations (27%), increased enforcement and penalties (9%), and addressing commercial fishing (9%).

CHAPTER I: DISCUSSION

Improving Our Understanding of Threats to Sharks

My findings add to a growing body of knowledge that suggests recreational anglers may plan an increasingly important role in the conservation and management of sharks. The results of my survey are similar to those of a study of recreational anglers across the United States, where the majority of anglers believe that sharks need to be protected, how one handles and releases a shark can influence the survival of the shark, and commercial fishers have a potential negative impact on the conservation of prohibited sharks (Press et al. 2016). It is not uncommon for user groups to assign blame to one another (Gallagher et al. 2016), so it was not surprising that recreational anglers would identify commercial anglers as a major risk to prohibited sharks. There seems to be some discrepancy about recreational anglers' contribution to shark conservation; in one instance, the overwhelming majority of respondents to my survey believe recreational angling presents harm to sharks (Table 1-2), while in another question, more than twice the number of anglers identified commercial anglers over recreational anglers as negative influences on the conservation of prohibited sharks (Figure 1-3).

Given that at least one third of respondents identify recreational angling as a risk to shark conservation (Figure 1-3), it is essential to assess how recreational anglers perceive the capture of sharks and to identify which capture and handling methods are used (Press et al. 2016). To achieve this, I wanted to learn if anglers were aware of best capture and handling practices and if they are adhering to those requirements. As required by the State of Delaware, only a slight majority of anglers self-reported keeping the shark in the water during release and removing the hook and gear from released sharks, with the implied caveat that it is difficult to remove the hook while the shark is in the water (n=6) (Appendix A). When asked to choose all actions taken when shark fishing, more anglers used circle hooks compared to J hooks, as now required by NMFS to maximize shark survivability. Circle hooks have been shown to be beneficial to some species (Willey et al. 2016), but this may not be true of all species. Although the use of circle hooks is recommended by NMFS as a best practice, it has been shown that hooks fitted onto blocker gangions are more successful at preventing deep hooking in Sand Tigers and can likely be applied to other shark species (see Chapter II). In a shore-based angling study on Delaware's coast, Sand Tigers captured were internally hooked on both circle hooks (54%) and J hooks (60%), likely due to Sand Tiger Shark's feeding mechanism which is characterized by swallowing prey (and the attached fishing hook) whole (Kilfoil et al. 2017). The use of blocker rigs by a small portion of my respondents is worth noting because the gear is thought to decrease the chance of internal hooking in the Sand Tiger Shark (Fox et al. 2015).

My findings suggest that anglers recognize sharks' importance and perceive that they are taking actions to minimize shark injury or mortality, despite not always adhering to either the State of Delaware requirements or the NMFS Cooperative Tagging Program's best practices (Press et al. 2016). Anglers may have chosen answers to avoid blame, in hopes of increasing the

chance of less restrictions to their fishing activities if additional management regulations were established (Gallagher et al. 2016). Moreover, recreational anglers may shy away from being honest about their actions when shark fishing due to fear that their fishing activities will be constrained by additional regulations. Anglers may fear punishment if they are non-compliant, which reduces the likelihood that violators will self-report and increases the chance that they will withhold or misreport information (Solomon et al. 2015). Respondents who self-identified as experienced shark fishers were critical of new anglers who participate in acts such as "landing sharks on the sand," deploying baits by kayaking or surfboards, and posting pictures on social media with sharks' mouths open or sitting on top of sharks. It seems that social media is a contributing factor to the negative conservation of sharks; inexperienced or misinformed anglers who post pictures showing incorrect handling of sharks may encourage other anglers to do the same especially when catching sharks is promoted and idealized in the media (e.g. television, angling magazines, and internet) (Danylchuk et al. 2014). Additionally, the NMFS recommends avoiding particular actions to maximize shark survivability of species that fishermen do not wish to keep as well as prohibited species (NOAA-NMFS 2013). Social media not only plays a part in spreading negative behaviors surrounding sharks, but the media in general is guilty of displaying sharks in a discouraging light. News networks, movies, and shows, such as some that are featured during Shark Week, show sharks as violent creatures, inciting fear of being attacked in many viewers who may not have a personal connection with sharks (Reifenberg 2016).

Many anglers believe they are knowledgeable about shark species identification, but their comments (Appendix A) demonstrate that they may be overly confident. Moreover, slightly less than half of anglers requested additional education and training that includes identification of species and proper handling techniques. Given the presumed uncertainty in identifying sharks

(Appendix A), I am skeptical that anglers are correct in the identification of species when claiming to mostly catch Sandbar Sharks (45%), along with Dusky (16%) and Bull (*Carcharhinus leucas*) (6%) Sharks. Dusky and Sandbar Sharks both have an interdorsal ridge (NMFS 2017) and are often confused with one another (SEDAR 2017); Dusky Sharks are often confused with other shark species that are legal to retain (NMFS 2017), such as the Bull and Blacktip (*Carcharhinus limbatus*). The misidentification between these three species, typically as juveniles, is a signal that recreational anglers may not be reporting the correct species. Anglers have shown a lack of assurance in identifying closely related species (Appendix A) and may be confident in their ability to identify a species, but they may not actually know how to differentiate between specific species (Chizinski et al. 2014). The likely confusion of prohibited Dusky and Sandbar Sharks with Bull and Blacktip Sharks is an example of why species identification is important for the reduction of the number of unknown and improperly identified sharks to improve quota monitoring (NMFS 2011). The difficulty in identifying closely related species is a potential problem with angler compliance because species are managed differently (Chizinski et al. 2014) where one may be allowed and the other prohibited. This issue of proper species identification is can be linked to anglers' adherence to regulations. Recreational fisheries are managed using regulations that rely on anglers' ability to properly identify captured fish (Chizinski et al. 2014). My survey respondents seem to be aware of minimum size restrictions, but unclear about which sharks are prohibited. The prohibited species and the corresponding shark regulations are listed on Delaware Division of Fish and Wildlife website (http://www.dnrec.delaware.gov/fw/Fisheries/Pages/SharkRegs.aspx) and in the 2018 Delaware Fishing Guide (http://www.dnrec.delaware.gov/fw/Fisheries/Documents/Fishing-Limits.pdf), but it seems that anglers are confused about discerning the difference between size

or creel limits and prohibition. Many of the species that respondents chose as being prohibited are authorized for retention but have regulations regarding landing and possession. It seems that the issue can stem from two areas: the uncertainty in identifying shark species and the question of species specific regulations.

Identifying Solutions to Shark Conservation Threats

Despite the media's negative influence on the public's perception of sharks, it can also be used to promote knowledge and positive attitudes toward these animals. Among anglers who fished in the last year, state agencies were consulted less frequently than magazines, websites, and television (Press et al. 2016; ASA 2017). Films highlighting shark conservation instead of their typical negative representation may contribute to the public's interest in shark conservation (Friedrich 2014). A decrease in the violence from sharks to humans shown in movies and television programs may help the public to disassociate violence with sharks, and therefore replace feelings of fear with of more positive images (Reifenberg 2016). Since social media is a driver of this inappropriate action, social marketing campaigns may be able to better influence behavior change (Solomon et al. 2015). It has also been shown that people with a personal connection to sharks or the marine environment through membership in environmental organizations, frequent aquarium visits, and encounters with sharks in the wild tend to have better knowledge of sharks and an improved understanding of the threats sharks face (Friedrich 2014). As another solution, there is space for environmental education through K-12 school curriculum, adult community education, or visits to aquariums or museums to be used as a compelling tool to create awareness of shark species and aid in proper species identification (Broadhead 2016).

With concerns of biases from respondents about their fishing activities, conservation scientists are tasked with providing evidence of the impacts of recreational angling on marine ecosystems (Gallagher et al. 2016). A communication-based intervention approach may be effective to ensure that rules are understood and increase anglers' knowledge about the biological impacts of improper behavior (Solomon et al. 2015). Public education surrounding current shark angling regulations and the effects of interaction with humans can minimize harm to species and may foster a better relationship with managers and anglers. Fisheries managers should be explicit when sharing findings that both support and negate this narrative and clearly explain how those findings influence new regulations or modifications to existing regulations. Shark fishing regulations were modified in Delaware when active targeting of Sand Tigers by charter fishers and shore-based shark tournaments that resulted in capture of prohibited species. The State of Delaware recognized the detrimental effect these actions had on the species and used that to support the new ruling that declares prohibited sharks cannot be removed from the water and must be released in a manner that minimizes harm. The State of Delaware has shown initiative in conserving prohibited sharks but despite their management efforts, there are still harmful interactions between anglers and sharks (Kilfoil et al. 2017).

Anglers seem to be undecided on the topic of if increased management will minimize harm to sharks during fishing and promote the conservation of sharks and were also divided on if there should be more or fewer regulations in Delaware. The fact that anglers are unsure about the value of current regulations is consistent with other findings (Press et al. 2016) and suggests that more regulations may not be the answer. Due to the complexity of individuals, motivations of behavior cannot be examined and intervened by just one approach. Instead, insight into designing more effective management that encourages compliance can be obtained through the

monitoring of compliant and non-compliant activities to determine when, where, with whom, and why they occur (Solomon et al. 2015).

Improving Shark Management

There are a few approaches to overcoming the issues of improper shark identification; the State of Delaware has produced a guide for commonly misidentified sharks but there is still a noted lack of education. The recently updated NOAA-NMFS Shark Identification (https://www.fisheries.noaa.gov/resource/outreach-and-education/shark-identification-placard) and newly created Prohibited Species (https://www.fisheries.noaa.gov/resource/outreach-and-education/prohibited-shark-identification-placard) placards are additional outreach material aimed to help Atlantic anglers properly identify shark species they encounter during fishing activities. As of January 2018, Highly Migratory Species permit holders who intend to fish for sharks are required to watch a video titled, "Atlantic Recreational Shark Fishing: Handling and Release of Prohibited Species" on shark identification and fishing regulations and complete a quiz to obtain a shark endorsement (NMFS 2017; https://hmspermits.noaa.gov/). The newly required training video and quiz are a step in the right direction to ensure that anglers are aware of fishing regulations and shark identification. The NMFS has laid out recreational, commercial, and stock indicators to assess the effectiveness of these new outreach materials. Based on anglers' false belief that they are complying or unwillingness to comply with NMFS Cooperative Tagging Program's recommendations, it seems that adoption of best catch-and-release practices holds promise but must be better disseminated (Press et al. 2016). Anglers noted that guides should possess better photographs of species and clearly state the regulations pertaining to each species listed. These new materials released by NMFS may be effective, but there are other ways

to ensure that anglers not only receive the best practice guides NOAA-NMFS and the State of Delaware produce, but also understand them.

Anglers at all skill levels should be provided with opportunities to learn fish identification, supporting the management of target species and angler compliance to regulations (Chizinski et al. 2014). My survey respondents were only adults, and thus, methods should be explored that reach that target audience, including approaches that use children as agents of change at home with their parents and in the community. When considering children as health change agents in Tanzania, it was found that students believe in their capacity to complete the task and showed commitment to doing so (Mwanga et al. 2007). Teachers and parents alike believed that children are quick learners and resourceful, therefore able to reach members of the community at various levels. Parents are likely to support the environmental sustainability children are promoting because it is pleasing to see their children's interest in environmental activism (Anderson 2016). It is important to note that children may not be successful at being intergenerational change agents if their families are unable to sacrifice their lifestyles for the sake of the environment and/or if families feel that they are too minor to create effectual change to a regional or global environmental issue through individual actions (Anderson 2016). In other words, this approach would only work if adults are open to receiving information from children and willing to change behavior long enough to develop new habits. It has been found that with youth aged 8 to 10 years old, fishing workshops less than 20 minutes in duration can lead to some improved fish condition at release (Palme et al. 2016). Specifically, trainings that involved visual aids and/or hands on demonstrations to illustrate best practices (e.g. having best practices for hook removal and handling techniques circled in green with the improper handling techniques circled in red and crossed out) produced the most highly trained participants. These

participants handled the fish for longer periods of time for the sake of being careful, used wet hands when handling the fish, and the fish experienced the least amount of air exposure (Palme et al. 2016). Although this approach was successful at teaching best practices, there was no insight on if the information from the workshop was retained or if this would be effective in older age groups. If the State of Delaware was to offer workshops for youth and adults, the State should also conduct follow up monitoring programs to provide insight into whether the behavior change is sustained and has a positive effect on the conservation of sharks.

Another tactic may be to increase the chances of being caught, the likelihood of prosecution and conviction, or the severity of penalties (Solomon et al. 2015). Unfortunately, it is not as simple as recommending more enforcement for anglers who will be encountering sharks during fishing activities; increased enforcement may raise resentment and challenge the perceived sincerity of authorities. It is also more difficult to monitor recreational angling as compared to commercial landings since enforcement is done at the discretion of whoever is patrolling the water on any given day and depends on if that individual observes the violation. In addition, enforcement records do not provide information of the potential drivers of the behavior (Solomon et al. 2015). Comparatively, direct questioning and self-reporting are characterized by under-reporting and heavy biases (Solomon et al. 2015); it is suspected that respondents may purposely lie to appear more socially admirable, known as social desirability response bias (Pasek and Krosnick 2010). Each approach has the ability to encourage conservation but may simultaneously leave out other pertinent information about anglers' motivations. The suite of interventions that promote compliance with conservation behaviors is extensive, and tactics should not be limited to one approach, but can be adopted to fit the issue at hand.

Value of this Angler Survey

As with any scientific endeavor, it is important to note limitations of a study. In the future, I would include changes in research design to provide more specific language for respondents. It is important to note that my study was unable to document differences in fishing practices with regards to targeting sharks based on fishing mode (e.g. boat versus shore). This result may be because a majority of the anglers who completed my survey did not target sharks. The question "do we need more or fewer regulations?" could be modified to say, "do we need more or fewer regulations for shark species?" Instead of using "surf" as an answer choice, I would replace the term with "shore-based angling" because that term is recognized by DNREC. There was some difficulty in ranking the order of preferential management options for two reasons; respondents chose multiple management options with the same ranking more than once. Restrictions should be set for this question so that each ranking can only be chosen once, and numerical ranking should be specified by preferential level. By performing the binomial logistic regression, I hoped to understand what factors make respondents believe that current management and restrictions will conserve sharks. Unfortunately, none of the factors were found to be significant in influencing the belief that current management and restrictions will conserve sharks. This may be due to an oversight in survey design by providing respondents with an "uncertain" option in response to the question if current management measures and restrictions will conserve sharks. It has been found that respondents who choose, "I don't know" do have a definitive opinion and researchers should discourage unsure responses to obtain valid data (Pasek and Krosnick 2010). Another possibility is that the factors may not be linked to the belief that current management and restrictions will conserve sharks, due simply to uncertainty. This

uncertainty is a recurring pattern in the results of my survey and may be indicative of stricter restrictions not being the answer to protecting sharks.

There have not been previous works in Delaware centering on the perceptions of recreational shark anglers. In fact, Kilfoil et al. (2017) suggests that based on their work on shore-angling in Delaware, a better understanding of angler motivations is imperative to conservation. My survey will hopefully serve as a first step to fostering an awareness of angler motivations, which is crucial due to the economic benefit recreational angling brings to the state of Delaware. In 2014, angler expenses on durable goods for marine recreational fishing in Delaware were $124 million, contributed 1,065 jobs to the state's economy, producing $96 million in sales, and $46 million in income (Lovell et al. 2016).

Future surveys could be focused on anglers who actively target sharks to assess their behaviors when capturing prohibited species. Organizations benefit from annual survey results to use during key planning periods, with the respondents' voice being present in discussions about priorities and goals, and as a guide in implementation strategies that are most likely to be successful (Hay Group 2013). Annual surveys aligned with the cycle of the fishing season can help to enhance the survey's visibility in the angling community, facilitate action planning, and integrate the survey in the standard annual planning process. The data from each annual survey should be used to identify areas for refinement and as tool to measure the effectiveness of education and outreach progress. This survey can be used as a tool for continuous monitoring of progress with compliance to achieve conservation objectives (Solomon et al. 2015). A year is sufficient time between surveys, providing time for the completion of short-term action plans and the initiation of long-term action plans, while ensuring that trend results are considered valid (Hay Group 2013). Given that anglers may be asked to take the annual survey in subsequent

years, providing actions resulting from their feedback has been found as a motivational tool to encourage responses by building long-term relationships (Oracle 2012). Additionally, mentioning the upcoming annual survey at the time of the current survey, especially during in-person encounters, gives the respondent something to look forward to and increases the likelihood of responses (Oracle 2012). Although angler surveys may require adjustments repeatedly before achieving the goal, this social science approach is the most promising for anglers to feel valued and therefore, ultimately improve shark conservation and recovery.

In the end, my survey filled a gap in understanding Delaware's recreational angler behavior regarding shark fishing. The survey highlights the need for improved angler education on shark species identification and handling techniques. The survey also revealed that the vast majority of anglers who target sharks are using circle hooks and removing hook and gear from sharks that are captured. However, only about half of the anglers who participated in the survey stated that they are using suggested protocols when shark fishing and adhering to regulations when capturing prohibited species. This issue of non-compliance can be resolved with a suite of approaches, including K-12 education, increased training, social media campaigns, and increased enforcement.

Table 1-1: Question type groups in the Gauging Angler Perceptions of Shark Fishing in Delaware Survey.

Group Type	Number of questions	Corresponding question
Respondent demographic data	3	What is your state of residency? What is your age? Please indicate the number of years you have been fishing.
Fishing preferences	4	When do you normally fish? Please choose all that apply. Please specify the number of hours you spend annually on each mode of fishing. Please choose all that apply. Please indicate "0" for each mode of fishing you do not use. Please specify the number of hours you spend annually for each option listed below. Other than shark, what is/are your primary target species?
Angler-shark interactions	5	I am comfortable with handling sharks. Anglers present no harm to sharks when fishing. If you specifically target sharks, please specify what number of hours you spend annually fishing for sharks. What sharks do you commonly catch? What do you do when shark fishing? Please choose all that apply.
Conservation knowledge	5	If I catch a shark, I am confident I will be able to identify it. There are currently minimum size restrictions on sharks in Delaware. There are currently no bag limits in place for sharks in Delaware. Please choose which of the following species are prohibited in Delaware. Please choose all that apply. Please identify which of the following may negatively influence the conservation of prohibited sharks. Please choose all that apply.
Management strategies	5	I believe prohibited sharks need to be protected. Please rank the following management options with regard to shark conservation based on your willingness to adopt them. Will current management measures and restrictions conserve sharks? Do we need more or fewer regulations? Do you have any suggestions for changes to shark management that will enhance the conservation of shark species?

Table 1-2: Mid-Atlantic anglers' agreement (or disagreement) regarding recreational angling and shark interactions in Delaware. Questions were rated on a Likert scale continuum; "somewhat agree" and "strongly agree" were combined into "agree", while "somewhat disagree" and "strongly disagree" were merged into "disagree." Results are based on 226 responses; margin of error is 6%.

Recreational angler – shark interactions in Delaware	**Agree (%)**	**Disagree (%)**
If I catch a shark, I am confident I will be able to identify it.	73%	27%
I am comfortable with handling sharks.	81%	19%
Anglers present no harm to sharks when fishing.	30%	70%
I believe prohibited sharks need to be protected.	84%	16%

Table 1-3: Preference for shark angling management options that Mid-Atlantic recreational anglers would be willing to accept; results are ranked from lowest to highest. Management options for each ranking level were determined by choosing the highest percentage of respondents for each level of ranking and some options were chosen for multiple ranking levels. Results are based on 226 responses; margin of error is 6%.

Ranking	**All respondents (n=226)**
First	Seasonal restriction (23%)
Second	Size limit (25%)
Third	Seasonal restriction (18%)
Fourth	Area restriction 23%)
Fifth	Leader restriction and Means of deployment[1] (19%)
Sixth	Leader restriction (19%)
Seventh	Means of deployment (20%)

[1] Deployment refers to bait type used (e.g. kayaking bait from the shore, chumming, etc.).

Table 1-4: Results from binomial logistic regression examining if demographic and behavioral factors of recreational anglers in the Mid-Atlantic region influence the belief that current management measures or restrictions will conserve sharks in Delaware. Results are based on 226 responses; margin of error is 6%.

Independent variable	Coefficient	Std. Error	z	P>z	95% Conf. Interval
Angler-shark interactions					
I believe prohibited sharks need to be protected	-0.0352	0.8550	-0.04	0.967	-1.7111, 1.6407
Anglers present harm to sharks when fishing	0.6619	0.8670	0.76	0.445	-1.0373, 2.3610
I am comfortable with handling sharks	-0.9248	0.8404	-1.10	0.271	-2.5720, 0.7224
If I catch a shark, I am confident I will be able to identify it	0.2289	0.8333	0.27	0.784	-1.4045, 1.8621
Demographic and behavioral variables					
Age of angler	0.0592	0.0407	1.46	0.145	-0.0205, 0.1389
Years fishing experience	-0.0640	0.0416	-1.54	0.124	-0.1455, 0.0176
Hours spent fishing from charter/head boat	0.0190	0.0256	0.74	0.457	-0.0311, 0.0692
Hours spent fishing from private boat	0.0003	0.0040	0.07	0.941	-0.0076, 0.0082
Hours spent fishing from the surf	-0.0002	0.0038	-0.06	0.953	-0.0077, 0.0072

Log-likelihood = 26.5242
Probability > χ^2 = 0.9049
Wald χ^2 (9) = 4.1

Table 1-5: Prohibited sharks captured on each fishing mode (i.e. charter/head boat, private vessels, and shore) based on responses of recreational anglers in the Mid-Atlantic region. Results are based on 226 responses; margin of error is 6%.

Fishing Mode	Sandbar	Sand Tiger	Dusky
Charter/head boat (n=101)	49%	32%	19%
Private vessels (n=157)	45%	27%	18%
Shore (n=186)	49%	29%	17%

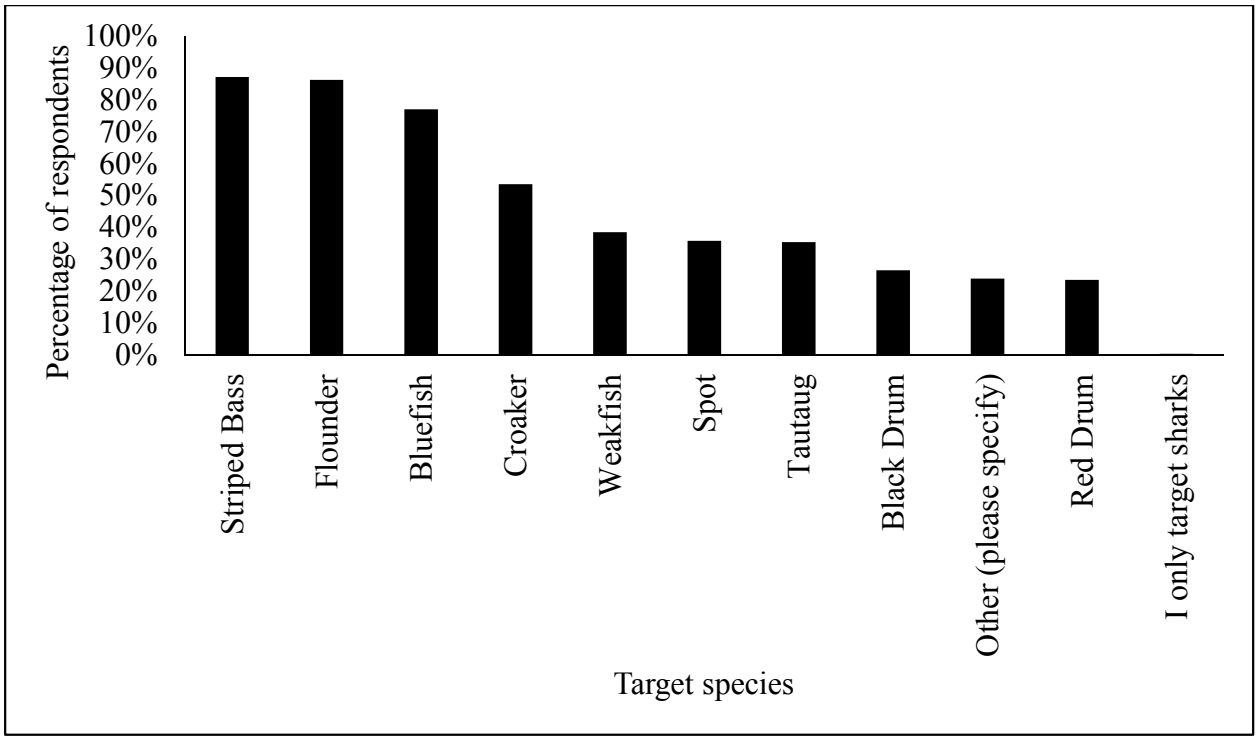

Figure 1-1: Primary target species of recreational anglers from the Mid-Atlantic region who fish in Delaware. Results are based on 226 responses; margin of error is 6%.

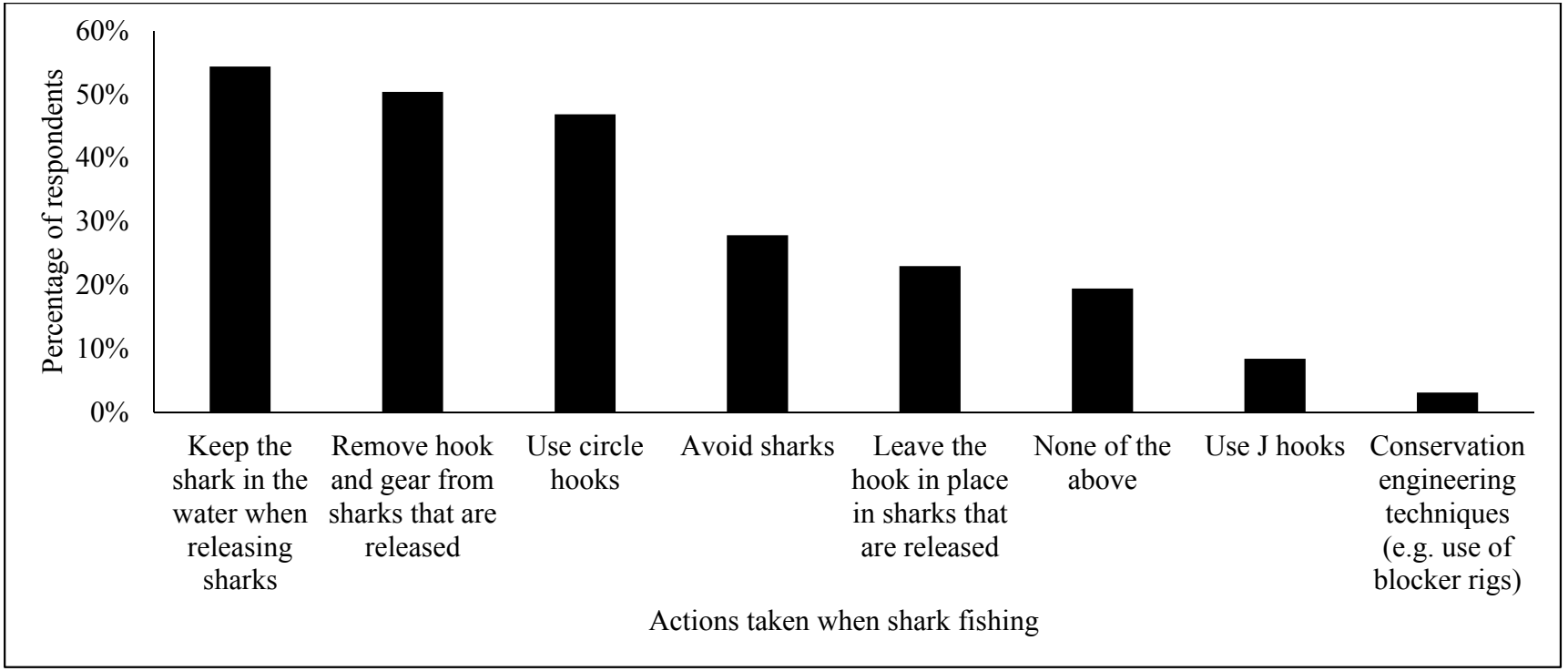

Figure 1-2: Actions Mid-Atlantic recreational anglers indicated taking when shark fishing in rank order (highest to lowest). Results are based on 226 responses; margin of error is 6%.

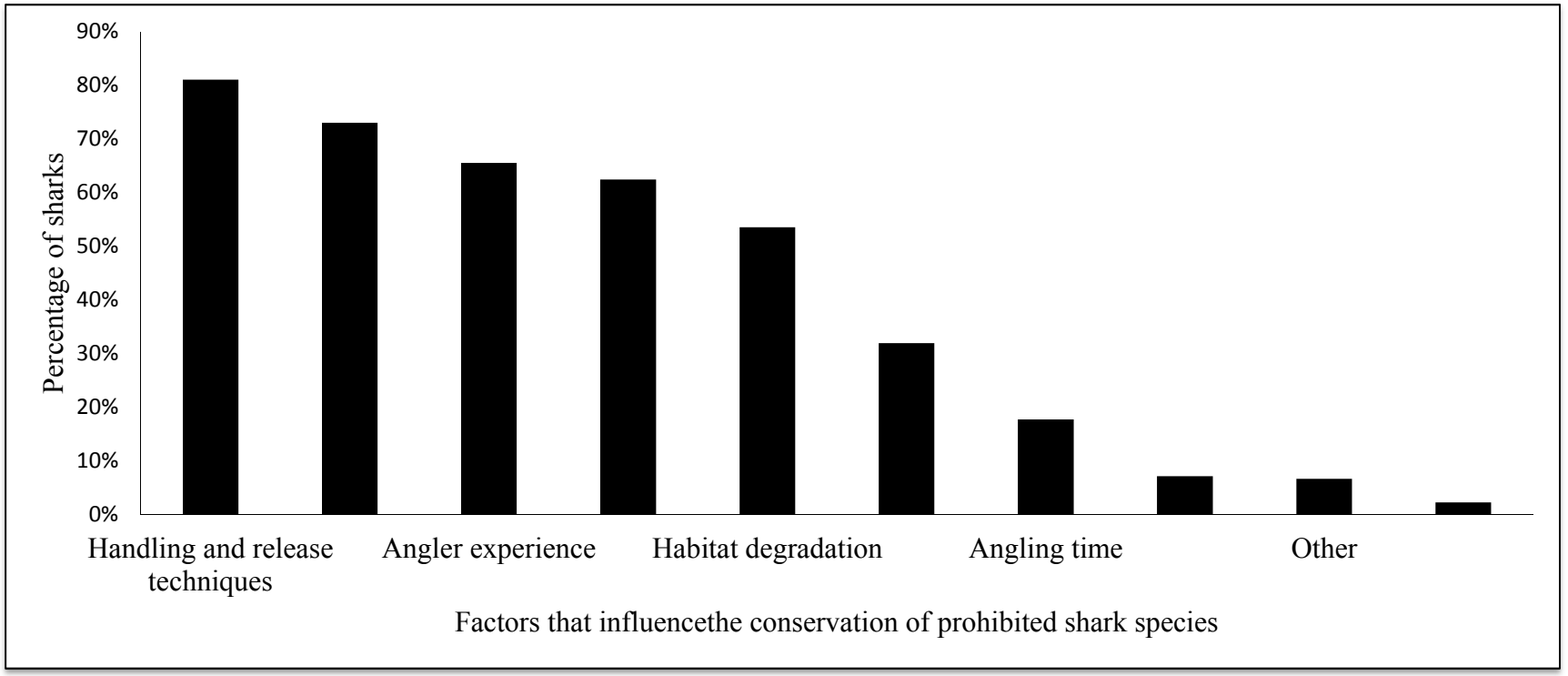

Figure 1-3: Factors that influence the conservation of prohibited sharks listed in rank order (highest to lowest), according to recreational anglers from the Mid-Atlantic region. Results are based on 226 responses; margin of error is 6%.

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CHAPTER II

THE INFLUENCE OF MODIFIED GANGIONS ON HOOKING LOCATION OF PROHIBITED SHARKS DURING LONGLINE SAMPLING IN DELAWARE

CHAPTER II: INTRODUCTION

Various studies focusing on conservation engineering and/or gear modifications have been conducted to reduce the negative impacts of incidental and targeted fishing efforts. The field of conservation engineering is diverse, covering work with gillnets, sound production, light manipulation, hook sizes/shapes, and many other approaches. The use of circle hooks and its performance compared to other hooks in recreational fisheries has been an area of recent research (Lewinson et al. 2004; Serafy et al. 2012). Circle hooks are being explored and occasionally recommended as a tool for reducing shark bycatch and/or increasing survival of sharks caught in hook and line fisheries (Serafy et al. 2012). Circle hooks have been shown to result in a higher hooking rate and capture rate than J hooks; and circle hooks had a lower deep-hooking rate and a higher proportion of sharks hooked in the jaw (Willey et al. 2016) which is important as hooking damage is relatively common in sharks and can impact post-release survival (Danylchuk et al. 2014). Generally, hooking a shark in the jaws area decreases the risk of post-release mortality and or other associated problems when compared to deep or internal hooking (e.g. gut) (Wolf-Christian et al. 2006). Studies have encouraged the use of circle hooks by state and federal agencies based on the premise that the use of circle hooks not only benefits the conservation of sharks, but also works in favor of the angler. Circle hooks require less maintenance than J hooks, reduce the capture rate of bycatch, and decrease the chances of deep hooking which can make hook removal difficult (Mapleston et al. 2008). However, the use of circle hooks may not be equally successful across all fisheries or species due to feeding mechanisms and/or biological traits. For example, Bluegill Sunfish (*Lepomis macrochirus*) have a small mouth making hook removal difficult such that deeply hooked fish either have the line cut or have the hook pulled out (Fobert et al. 2009). As another example, Sand Tigers

(*Carcharias taurus*) possess a biological trait known as gulp feeding where they swallow prey whole, increasing their susceptibility to angling impacts. Gulp feeding can contribute to internal hooking potentially damaging major organs (e.g. esophagus, stomach and liver, pericardium) and increase the likelihood of mortality (Lucifora et al. 2009). An investigation on the feeding habits of Sand Tigers in the Argentine recreational fishery noted that the vast majority of individuals that swallowed the hook were hooked in the internal organs, causing damage such as occlusion and perforation of the esophagus and stomach, and lacerations to the pericardium, heart, and liver (Lucifora et al. 2009).

Sand Tigers are one species for which recreational angling has been identified as a possible conservation threat although there presently no directed fishery in the U.S. Sand Tiger populations have declined over the past several decades due to high rates of harvest in commercial and recreational fisheries (Musick et al. 1993; NMFS 2009). Historically, the species was targeted and/or taken as bycatch throughout its range (Compagno 1984; Musick et al. 1993). Sand Tigers were listed as "vulnerable," defined as at risk of becoming endangered or threatened within a short period of time, due to their extremely low fecundity and low intrinsic rate of increase (Musick et al. 2000). As a result, a suite of management strategies, including prohibition of harvest and mandated release, have been implemented to reduce fishing mortality in commercial and recreational fisheries (ASMFC 2010; NMFS 1999; NMFS 2009; United States Office of Federal Registrar (USOFR) 1997). As a prohibited species, it became illegal to harvest or retain Sand Tigers or any of their parts in recreational and commercial fisheries on the U.S. Atlantic coast and in the Gulf of Mexico (United States Office of Federal Registrar 1997). Sand Tigers were added to the Species of Concern list in 2004, and in the Shark Interstate Fisheries Management Plan for State Waters, all states from Florida to Maine and the Gulf of Mexico were

banned retention or possession of Sand Tigers (ASMFC 2010). Although mandatory release policy effectively reduces directed mortality, its true efficiency is reliant on the ability of Sand Tigers to recover from and survive interactions with fishing gear (Kneebone 2012). Despite commercial and recreational anglers being prohibited from landing Sand Tigers since 1997, there is growing concern over the impact of targeted catch-release angling (Fox et al. 2015, Kilfoil et al. 2017).

Sand Tigers' coastal preference makes them vulnerable to recreational angling, and there has been a recent increase in the amount of anglers targeting Sand Tigers in the mid-Atlantic (Kilfoil et al. 2017). A study in Delaware's coastal waters was conducted in 2012-2013 to assess the impact of recreational angling on shore-caught Sand Tigers through passive acoustic telemetry (Kilfoil 2014). The majority of Sand Tigers that were captured during this cooperative shore-based angling project were internally hooked and retained gear, regardless of hook type (J or circle) or sex (Kilfoil 2014). This knowledge contributes to the growing body of evidence to suggest that gut hooking occurs at a high rate for Sand Tigers captured during angling. In a recreational angling study on juvenile Sand Tigers in Massachusetts, it was observed that regardless of the use of circle hooks, internal hooking occurred 42% of the time (Kneebone et al. 2013). Although very few released individuals suffered immediate mortality, delayed mortality (50-100 days) was estimated between 18-28% for internally hooked individuals (Kneebone et al. 2013). As such, development of better fishing gears and fishing practices, resulting in low post-release fishing injury or mortality rates, is vital for the survival of Sand Tigers.

Sand Tigers exhibit high levels of site fidelity to Delaware (Kilfoil et al. 2017), and thus are susceptible to recapture and repetitive injury (Fox et al. 2015). Sharks with a high degree of site fidelity may be more accessible to recreational anglers and therefore, more susceptible to

impacts related to angling (Danylchuk et al. 2014). In Delaware waters, Sand Tiger recapture rates were high and there was evidence of multiple in-season recaptures (Kilfoil 2014). Repeated events can increase the probability of injury, thus increasing the potential for cumulative negative effects, such as mortality (Kilfoil 2014). As a result of the apparent concern for reducing injury and mortality of Sand Tigers, a conservation plan was developed to restore the US northwest Atlantic Sand Tiger population to a level that allows them to be removed as a Species of Concern (Fox et al. 2015). This plan includes an assessment of the potential threats facing mid-Atlantic Sand Tigers and identifies recreational fishing as having a high impact relative to recovery. This issue was recently brought to the public's attention when an emergency ordinance was signed banning chumming or blood-baiting from the beach or within 600 feet of the beach at any time in Ocean City, Maryland (City Council of Ocean City, Maryland 2016).

Given the negative impacts of internal hooking on Sand Tigers, management should strongly consider the use of other gear modifications to circle hooks which could allow for less injury and stress to Sand Tigers. The gear and methods recreational anglers use may play a significant role in fish survivorship (Press et al. 2016). The modification of leaders could serve as a valuable development for reducing post-release mortality rates in Sand Tigers. Captain Mark Sampson (F.V. Fish Finder) is commonly credited with the development of modified "blocker rigs" as a conservation tool for catch and release shark fishing (http://bigsharks.com/blocker-rig-study/). When he observed a 5-10% gut-hooking occurrence using circle hooks, Captain Sampson began investigating the use of various rigs and hooks that would ensure sharks would be hooked in the jaw when caught. Using this gear modification, the objective of this study was to examine the influence of gangions fitted with blockers on hooking locations for Sand Tigers captured on bottom longlines.

CHAPTER II: METHODS

Study Site

Exploratory fishing for Sand Tigers in Delaware Bay was initiated in 2007 and was coupled with intensive longline fishing surveys conducted during 2008-2014 (Fox et al. 2015) identified concentration areas. Delaware Bay covers approximately 2,000 km^2 with an average depth of 6.3 m (Kraft 1991); the bay has extensive shoals (one to four meters deep), sloughs/channels (five to nine meters deep) and shipping channels (nine to 46 meters deep) (NOAA 1985). With this knowledge we conducted targeted sampling during daylight hours areas where telemetry evidence suggested greatest Sand Tiger occupancy of the Delaware Bay.

Sampling Methods

I examined the influence of experimental (blocker) gangions on capture rates and hooking locations for Sand Tigers, using a modified large shark NOAA-NMFS Apex Predator Program survey longline, comprised of a 366 m mainline baited with Menhaden (*Brevoortia tyrannus*) and a 60-120-minute soak time. The monofilament mainline was outfitted with 24 monofilament leaders (or gangions) that ended with (16/0) barb depressed circle hooks split equally between control (regular gangion) and experimental blocker gangions. The blocker gangions were comprised of a 30.5 cm section of 1.3 cm PVC flexible pipe swaged perpendicularly with an alloy crimp 20.3 cm above the eye of the circle hook (Figure 2-1). In 2012, gangions were placed randomly throughout the longline; to determine the placement of gangions type (control vs. experimental), a random number generator in Microsoft Excel was used. During sampling in 2013, gangions were placed in an alternating pattern for each set. In 2014, cooperative sampling was carried out by the University of Delaware and only blocker gangions were used to minimize harm when capturing Sand Tigers, while reducing the chances

of capturing Sandbar Sharks (*Carcharhinus plumbeus*). Longlines were hauled to the vessel where the sharks were fitted with external DART tags at the base of the first dorsal fin while still in the water but secured to the boat with a tail rope. For the purposes of this study, the following was noted as each longline was hauled: species identification, sex, length (TL and FL cm), gear type, hook location (jaw or gut (included throat)), and post release condition. Sand Tiger size at maturity estimated at 220-230 cm TL for females and 190 cm TL for males (Goldman 2002). Neonate Sandbar Sharks are classified as being 43-52 cm FL (Brewster-Geisz and Miller 1999) and mature females are at least 150 cm FL; large Sandbar Sharks are greater than 180 cm (Sminkey and Musick 1995). Genetic samples were collected and the antibiotic, oxytetracycline (OTC Bio-Mycin, 10mg/kg of bodyweight) was administered to the animal before release due to its staining characteristic which can be used to determine age.

Analysis

For my analysis, I focused on the two most commonly encountered species, Sandbar and Sand Tiger Sharks, to better provide a more comprehensive examination of the effect of hook type on prohibited species. Using Pearson's Chi-Squared Test, I examined the relationship between gangion type and hook location, condition at release, and sex for Sandbar Sharks and Sand Tigers (Bacheler and Buckel 2004). When values were too small, they did not produce correct assumptions of p-values, so I repeated the test with 2000 replicates to produce a simulated p-value (Bacheler and Buckel 2004). I used a T-test to compare the number of sharks captured on each gangion type (control vs. experimental). I developed a bionomial logistic regression model to examine the impact of gear type on hooking location of captured Sand Tigers. Hook location was coded as "0" = jaw and "1" = gut (including throat); control gangions

were coded as "1" and blocker gangions were coded as "2". Inference for all statistical analyses was made at $\alpha = 0.05$. All statistical analyses were carried out in R Studio.

CHAPTER II: RESULTS

Field Collections

The 2012 sampling season was initiated on July 5 and concluded on September 24, during which period 77 longline sets occurred. In 2013 sampling took place from July 19 through September 11 and comprised 40 longline sets. The final year of sampling was carried out by collaborators with the University of Delaware and ranged from July 9 through September 2, 2014 comprising 36 longline sets. Over the course of this three year directed sampling, a total of 867 elasmobranchs were captured comprised of the following species: Sand Tiger (n=493) Sandbar Shark (*Carcharhinus plumbeus*) (n=240), Smooth Dogfish (*Mustelus canis*) (n=126), Clearnose Skate (*Raja eglanteria*) (n=5), Cownose Ray (*Rhinoptera bonasus*) (n=1), and unidentified stingray species (n=2) (Table 2-1).

Male Sand Tigers dominated (57.6%, n=363) catches in both years of comparative sampling (2012 and 2013). A majority (67.4%) of male Sand Tigers were mature while 27.3% off females were mature (Figure 2-3). In 2014 when only experimental (blocker) gangions were employed, females (55.9%, n=118) dominated the catch compared to males (44.1%) (Table 2-2). Female Sandbar Sharks dominated (79.6%, n=186) the catch in both years of comparative sampling (Table 2-3), of these 11 individuals (all females) were mature (Figure 2-4). In 2014 when only experimental (blocker) gangions were used in sampling, the majority (64.3%, n=42) of Sandbar Sharks were female (Table 2-3).

Impacts of Gear Type

Overall landings of Sand Tigers were significantly reduced (T-test p = 0.024) when using experimental (blocker) gangions (2012, 39.6%; 2013, 41.4%) compared to control gangions (2012, 60.4%; 2013, 58.6%) in both years of comparative sampling (Table 2-2). In 2012, gear type influenced the sex of captured Sand Tigers ($\chi^2 = 7.4375$, df = 1, p = 0.006) whereas there was no significant difference ($\chi^2 = 2.3647$, df = 1, p = 0.124) in the sex of individuals caught in 2013. In 2012, landings of female Sand Tigers were distributed nearly equally between gears (blocker 49.5%; control 50.1%) while males were collected over twice as commonly on the control gangions (67.5%) compared to experimental (blocker) gangions (32.5%) (Table 2-2). In 2013, females were again distributed nearly equally between gears (blocker 51.2%; control 48.8%) although over twice as many males were collected on the control gangions (67.3%) than on blocker gangions (32.7%) (Table 2-3).

Sandbar Sharks were caught at significantly higher levels (T-test, p = 0.013) on control gangions (63.1% (n=157)) when compared to experimental (blocker) gangions in 2012. During both years of comparative sampling, overall catches were lower on experimental (blocker) gangions as compared to control gangions (Table 2-3). Gangion type did not have an effect on the sex of captured Sandbar Sharks in either 2012 ($\chi^2 = 1.8061 \times 10^{-30}$, df = 1, p = 1) or 2013 ($\chi^2 = 0.119$, df = NA, p = 1). In 2012, both females and males were collected almost twice as often on the control gangions (63%) compared to experimental (blocker) gangions (37%). In 2013, females were distributed closely between gears (experimental (blocker) 57.1%; control 42.9%) while males were collected equally on control (50%) and experimental (blocker) gangions (50%).

Gear type did not appear to influence release condition of Sand Tiger (Table 2-4) or Sandbar (Table 2-5) Sharks captured in both years of comparative gear sampling. In 2012, Sand

Tigers captured on experimental (blocker) gangions were classified as being in “excellent” (24.8%), “average” (70.5%), and “poor” (4.8%) condition, while those on control gangions were “excellent” (20.1%), “average” (69.8%), and “poor” (10.1%) condition ($\chi^2 = 3.512$, df = NA, p = 0.306). In 2013, Sand Tigers captured on experimental (blocker) gangions were classified as being in “excellent” (34.2%), “average” (65.8%) (none were classified as “poor”) condition, while those on control gangions were “excellent” (24.1%), “average” (70.4%), and “poor” (5.6%) condition ($\chi^2 = 2.9297$, df = NA, p = 0.254). In 2014 using only experimental (blocker) gangions, 9% of Sand Tigers were released in “excellent” condition, 88% were “average,” and 3% were in poor condition. In 2012, Sandbar Sharks captured on experimental (blocker) gangions were classified as being in “excellent” (47.5%), “average” (50.8%), and “poor” (1.7%) condition, while those on control gangions were “excellent” (45.5%), “average” (42.4%), and “poor” (12.1%) condition ($\chi^2 = 6.0999$, df = NA, p = 0.087). Sandbar Sharks that were captured in 2013 on experimental (blocker) gangions were classified as being in “excellent” (57.1%), “average” (21.4%), and “poor” (21.4%) condition, while those on control gangions were “excellent” (40%), “average” (46.7%), and “poor” (13.3%) condition ($\chi^2 = 2.9656$, df = NA, p = 0.442). In 2014, when only the experimental (blocker) gangions were employed, Sandbar Sharks were categorized as "average" (75.6%), "excellent" (12.2%), and "poor" (12.2%) condition at release.

Hooking Location

Gear type significantly ($\chi^2 = 9.228$, df = NA, p = 0.003) influenced hook location (gut vs. jaw) in Sand Tigers (Table 2-6). The overwhelming majority of Sand Tigers captured on experimental (blocker) gangions (97.9%) were hooked in the jaw while the use of control gangions resulted in increased levels of gut hooking (25.6%) (Table 2-7). In 2014, using only

experimental (blocker) gangions the vast majority of Sand Tigers were hooked in the jaw (93.1%).

No Sandbar Sharks were gut hooked during the course of this study (Table 2-8). In 2012, 62.8% (n=156) of Sandbar Sharks were captured on control gangions whereas catches were split equally between gear types during 2013. During sampling in 2014, 100% of Sandbar Sharks were hooked in the jaw using the experimental (blocker) gangions.

CHAPTER II: DISCUSSION

Although it has been a challenge to develop and employ selective fishing techniques or gear to reduce ecological and environmental impacts in fisheries (Boopendranath and Pravin 2009), numerous studies have been done to explore minimizing the incidental capture and/or associated injury of species (e.g. Boopendranath and Pravin 2009, Brill et al. 2009, Bostwick et al. 2014; Al-Baz and Chen 2014). In this study, modified gangions may provide a useful tool toward protecting Sand Tigers from the negative impacts of angling. Although broad scale survey information is lacking the US, in Australia, it was reported that over half of diver-observed Sand Tigers had retained fishing gear or jaw injuries resulting from capture, which ultimately may have resulted in mortality (Bansemer and Bennett 2010).

Hook type is widely known to influence the hooking location in many species (Bacheler and Buckel 2004), and is often employed as an effective management strategies to prevent preventable losses of species. Given that circle hooks do not effectively minimize injury to Sand Tigers (Kilfoil et al. 2017), blocker gangions show promise in longline trials, as well as recreational shark fishing (carried out by Captain Mark Sampson) where sampling showed a near 100% success rate at preventing gut hooking and a 50:50 relationship in capturing sharks as compared to a circle hook (http://bigsharks.com/blocker-rig-study/). Gear type did influence

hook location for Sand Tigers in both years of sampling; it is evident that blocker gangions are successful at hooking Sand Tigers in the jaw instead of the gut as compared to control gangions. The adoption of blocker gangions has been confirmed in this study to reduce the incidence of gut hooking in Sand Tigers during a bottom longline survey.

The benefits of catch and release shark angling can only be valuable in conservation if the impacts on released individuals are minimized (Danylchuk et al. 2014). The use of blocker gangions may appealing to anglers because the high likelihood of jaw hooking will reduce concerns associated with removing hooks while the shark is in the water (see Chapter I). If the use of blocker gangions increases the degree to which recreational anglers have a more enjoyable experience by allowing them to release the shark with less difficulty, they may be more willing to adopt them during fishing activity. Therefore, given that experimental (blocker) gangions have been shown in this study to reduce the risk of injury of Sand Tigers, and in recreational angling on a boat (Mark Sampson, unpublished data) to reduce deep hooking of sharks, the use of blocker gangions may be voluntarily adopted by recreational anglers. It is possible that recreational anglers who are interested in releasing their catch alive and with minimal injury would be more willing to voluntarily adopt gear that increases those chances (Wilson and Diaz 2012). However, promoting the use of blocker gangions could also have the potential to continue or increase angling pressures on Sand Tigers and other prohibited species (Fox et al. 2015). Additionally, there is a need to consider that if anglers fail to remove the hook and settle on cutting the line upon release of a captured shark, the presence of the blocker may impact feeding habits and swimming patterns more significantly than a standard hook and leader. Despite the trials done within my study and by Captain Mark Sampson, I suggest still more research to be carried out with recreational anglers to modify the gear so that it ensures user confidence as well

as conservation. It is important to consider that potential gear modifications be designed with the input of recreational anglers (Fox et al. 2015) in order to effectively remove directed pressures on prohibited species while still obtaining other target species. Sufficient communication with and participation of stakeholders can prevent or minimize conflict, and the involvement of anglers in management decisions may minimize the problem of noncompliance (Lewin et al. 2006). Recreational anglers were not in favor of a leader restriction when asked to choose management options that they would be willing to adopt (see Chapter I). Modified leaders should be further developed in design and implementation for use in the recreational angling community. There should be more examination of the effect of blocker leaders when targeting other species of shark and if they are just as successful in different modes of fishing.

The employment of modified gangions as a standardized sampling tool reduced injury for targeted Sand Tigers. Recognizing that Delaware Bay hosts one of the largest summer foraging areas for Sand Tigers in the Northwest Atlantic, increased scientific survey efforts have resulted in over 1,000 landed Sand Tigers since 2007 using standard bottom longlines in Delaware State University and/or University of Delaware's studies. Thus, when scientific surveys are being conducted, scientists should consider using the most humane techniques available when sampling populations that are in decline and in need of restoration (Heupel and Simpfendorfer 2010). Similarly, those who obtain sharks for the aquarium trade should do so with the upmost consideration in protecting the species. Sand Tigers have been listed as one of the top five popular sharks for public aquariums (Morris et al. 2010). Management agencies should consider requiring the use of blocker rigs for aquaria collections either targeting Sand Tigers or scientific surveys in areas of high Sand Tiger concentration given the high incidence of deep hooking and potential trauma when using circle or J hooks. Simple, economically feasible gear modifications

have been found to efficiently reduce bycatch and mortality of those species captured on longline (Afonso 2011). The production of blocker gangions is simple and can be produced relatively cheaply. It is worth noting that Sandbar Sharks are less likely to be caught on blocker gangions and therefore, would not be effective for aquaria or scientific surveys targeting this species, but blocker gangions should be used in areas where both Sandbar and Sand Tigers occur. In the end, the use of experimental (blocker) gangions should be promoted for use by both the aquaria and scientific communities to improve the conservation of Sand Tigers. It is my hope that with further modification this technique the use of this relatively simple but effective tool may find wide-spread use in the recreational angling community to reduce fishing injury of Sand Tigers thereby enhancing recovery prospects of this imperiled species.

Table 2-1: All species captured by year during a standardized bottom longline survey in Delaware Bay in 2012-2014.

Species	Number Caught		
	2012	**2013**	**2014**
Clearnose Skate (*Raja eglanteria*)	0	3	2
Cownose Ray (*Rhinoptera bonasus*)	0	1	0
Sandbar Shark (*Carcharhinus plumbeus*)	162	32	46
Sand Tiger Shark (*Carcharias taurus*)	270	101	122
Smooth Dogfish (*Mustelus canis*)	0	93	33
Unidentified Stingray	0	0	2

Table 2-2. Composition of Sand Tigers by sex and gear type (experimental (blocker) and control) captured during a standardized bottom longline survey in Delaware Bay in 2012-2014.

2012	Number Caught	2013	Number Caught	2014	Number Caught
Female	111	**Female**	43	**Female**	66
Blocker	55	Blocker	22	Blocker	66
Control	56	Control	21	**Male**	52
Male	157	**Male**	52	Blocker	52
Blocker	51	Blocker	17		
Control	106	Control	35		
Total	268	**Total**	95	**Total**	118

Table 2-3. Composition of Sandbar Sharks by sex and gear type (experimental (blocker) and control) captured during a standardized bottom longline survey in Delaware Bay in 2012-2014.

2012	Number Caught	2013	Number Caught	2014	Number Caught
Female	127	**Female**	21	**Female**	27
Blocker	47	Blocker	12	Blocker	27
Control	80	Control	9	**Male**	15
Male	30	**Male**	8	Blocker	15
Blocker	11	Blocker	4		
Control	19	Control	4		
Total	157	**Total**	29	**Total**	42

Table 2-4. Release condition by gear type (experimental (blocker) and control) of Sand Tigers captured during a standardized bottom longline survey in Delaware Bay in 2012-2014.

2012	Number of Sharks	2013	Number of Sharks	2014	Number of Sharks
Blocker	105	**Blocker**	38	**Blocker**	117
Excellent	26	Excellent	13	Excellent	11
Average	74	Average	25	Average	103
Poor	5	Poor	0	Poor	3
Control	159	**Control**	54		
Excellent	32	Excellent	13		
Average	111	Average	38		
Poor	16	Poor	3		
Total	264	**Total**	92	**Total**	117

Table 2-5: Release condition by gear type (experimental (blocker) and control) of Sandbar Sharks captured during a standardized bottom longline survey in Delaware Bay in 2012-2013.

2012	Number of Sharks	2013	Number of Sharks	2014	Number of Sharks
Blocker	59	**Blocker**	14	**Blocker**	44
Excellent	28	Excellent	8	Excellent	6
Average	30	Average	3	Average	32
Poor	1	Poor	3	Poor	6
Control	99	**Control**	15		
Excellent	45	Excellent	6		
Average	42	Average	7		
Poor	12	Poor	2		
Total	158	**Total**	29	**Total**	44

Table 2-6. Results of binomial logistic regression analysis examining the impact of gear type (experimental (blocker) and control) on hook location for Sand Tigers captured in a standardized bottom longline survey in Delaware Bay during 2012-2013.

Deviance Residuals				
Minimum	1st Quartile	Median	3rd Quartile	Max
-0.7729	-0.7729	-0.2052	-0.2052	2.7825
Coefficients				
	Estimate	Standard Error	z-value	Pr (>|z|)
(Intercept)	1.7396	0.6621	2.627	0.00861**
Gear Type	-2.7949	0.6041	-4.627	$3.71e^{-06}$***
Null deviance: 316.83 on 356 degrees of freedom				
Residual deviance: 272.49 on 355 degrees of freedom				
AIC: 276.49				
Number of Fisher Scoring iterations: 6				

Table 2-7. Hook placement (gut or jaw) of Sand Tigers (number of individuals) by gear type (experimental (blocker) and control) and sex captured during a standardized bottom longline survey in Delaware Bay in 2012-2014.

2012	Number Caught	2013	Number Caught	2014	Number Caught
Blocker	106	**Blocker**	40	**Blocker**	116
Gut	3	Gut	0	Gut	8
Jaw	103	Jaw	40	Jaw	108
Control	160	**Control**	55		
Gut	44	Gut	11		
Jaw	116	Jaw	44		
Total	266	**Total**	95	**Total**	116

Table 2-8. Hook placement of Sandbar Sharks (number of individuals) by gear type (experimental (blocker) and control) and sex captured during a standardized bottom longline survey in Delaware Bay in 2012-2014. 100% of Sandbar Sharks were caught in the jaw and none in the gut.

2012	Number Caught	2013	Number Caught	2014	Number Caught
Blocker	58	**Blocker**	16	**Blocker**	43
Jaw	58	Jaw	16	Jaw	43
Control	98	**Control**	16		
Jaw	98	Jaw	16		
Total	156	**Total**	32	**Total**	116

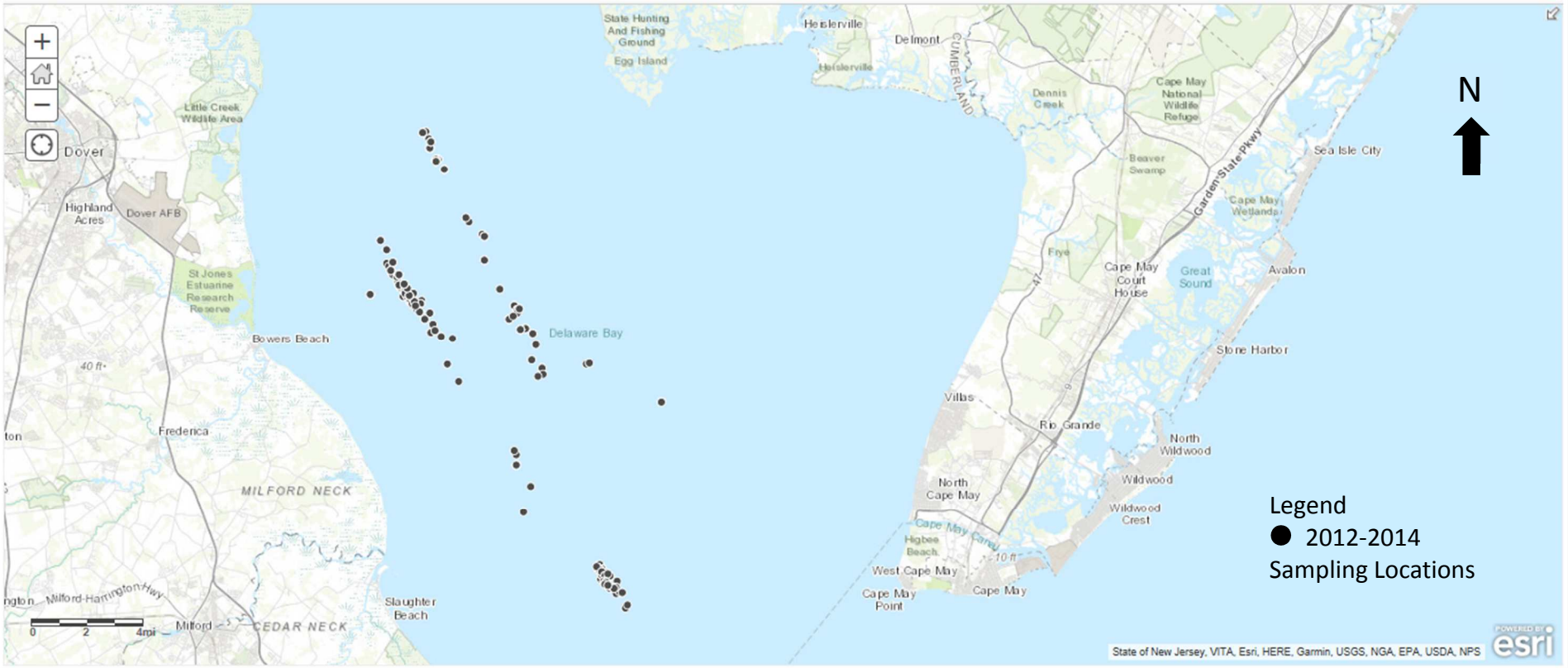

Figure 2-1. Location of sampling sites during a standardized bottom longline survey in Delaware Bay in 2012-2014.

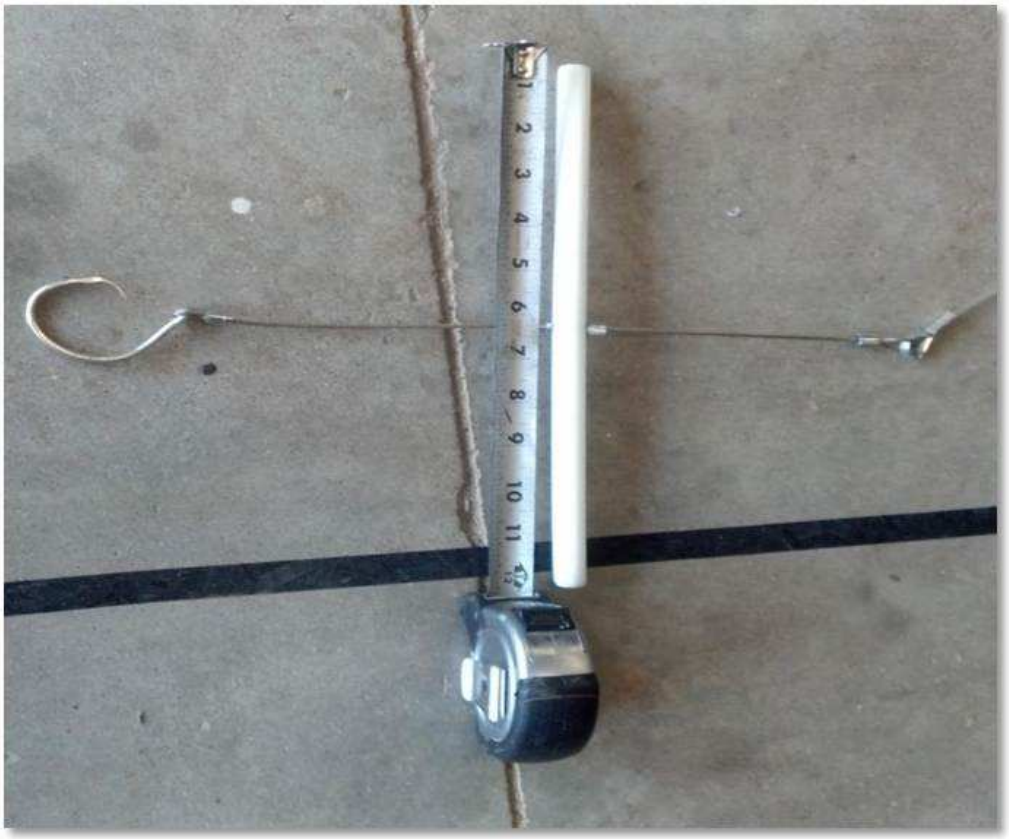

Figure 2-2: Modified longline gangion “blocker”, developed to reduce Sand Tiger mortalities during fishing. Blocker gangions were comprised of a 30.5 cm section of 1.3 cm PVC flexible pipe swaged perpendicularly with an alloy crimp 20.3 cm above the eye of the circle hook.

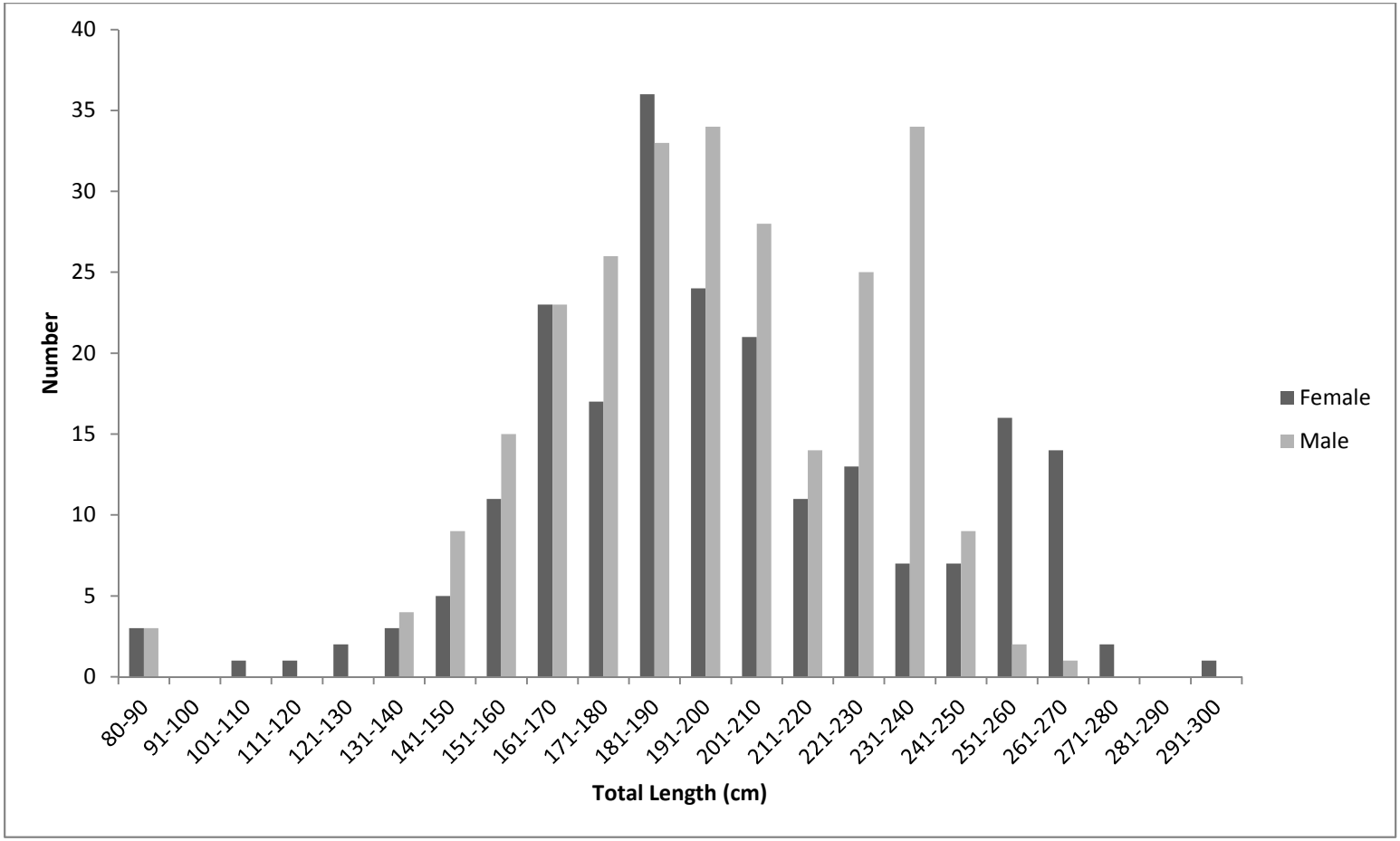

Figure 2-3. Number of Sand Tigers captured by sex during a standardized bottom longline survey in Delaware Bay in 2012-2014. Data are shown in 10 cm interval size classes. Size at maturity estimated at 190 cm TL for males and 220-230 cm TL for females (Goldman 2002).

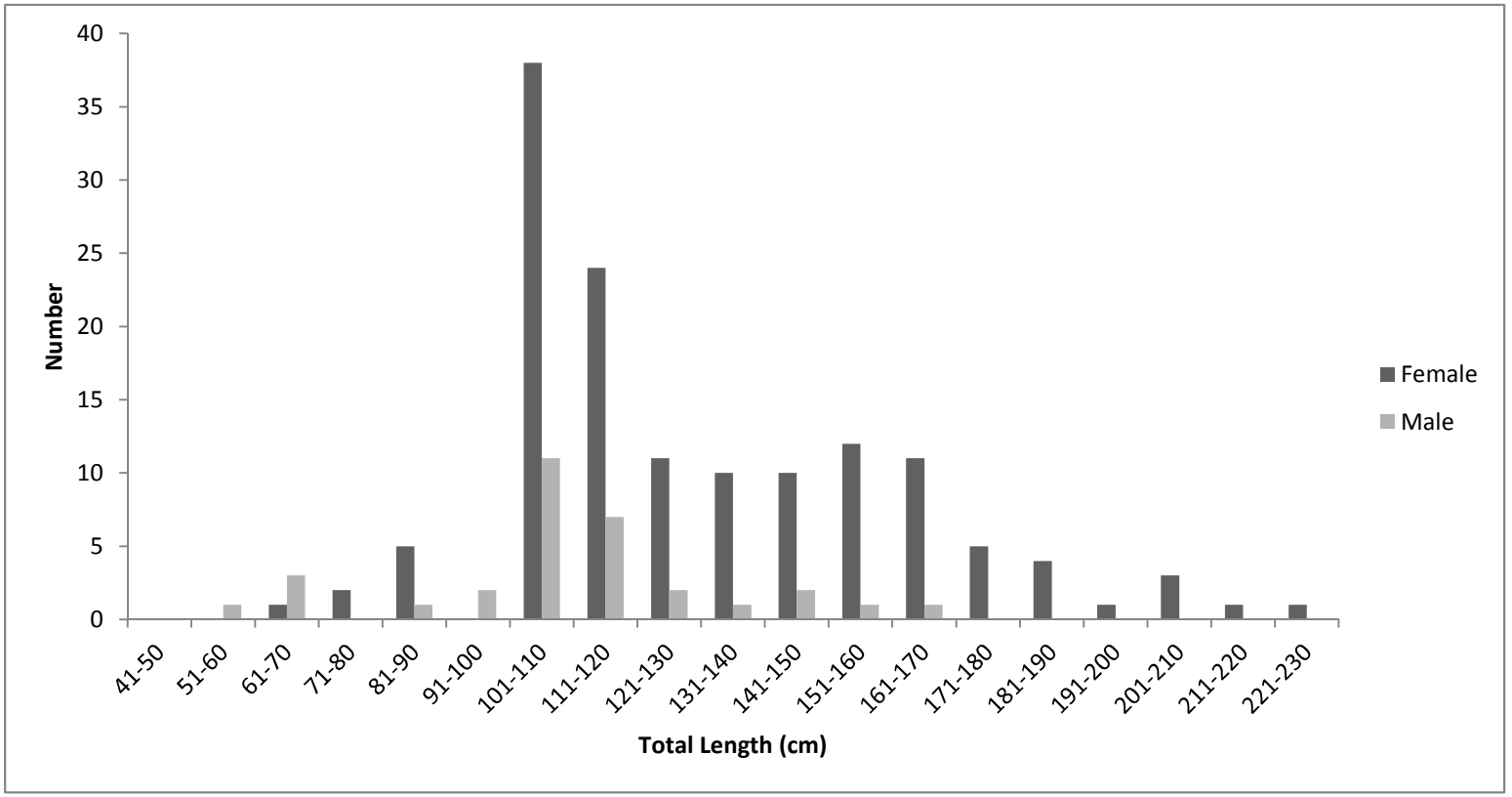

Figure 2-4. Number of Sandbar Sharks captured by sex during a standardized bottom longline survey in Delaware Bay in 2012-2014. Data are shown in 10 cm interval size classes. Neonate Sandbar Sharks are classified as being 43-52 cm FL (Brewster-Geisz and Miller 1999) and mature females are at least 150 cm FL; large Sandbar Sharks are greater than 180 cm (Sminkey and Musick 1995).

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APPENDIX A

Responses to “Do you have any suggestions for changes to shark management that will enhance the conservation of shark species?” Responses are categorized from 93 recreational anglers in the Mid-Atlantic region; margin of error is 9%.

Education and training
More education to potential shark fishermen on ID and release techniques.
Educate the people that kill and leave on the beach.
Perhaps a shark specific stamp in addition to base fishing license. This would lessen those targeting sharks for "fun" and help fund further research and conservation.
Maybe some better pictures and descriptions on different shark species in the fishing guide book. I know there has been times where I wasn't 100% sure on exactly what I caught.
Species identification education.
Better pictures in fishing guide.
More public education.
Show people how to release a shark in good condition.
My best idea to help sharks stay safe is to have someone who works for NOAA or any other fishing agency with credibility to observe each shark angler and make a decision if they are probably catching and releasing sharks. In my opinion, that will eliminate the anglers who don't know how to properly handle them. I feel like it's wrong to target every angler who shark fish because some do know how to keep sharks safe and it's unfair to place any regulation on the anglers to know how to properly handle sharks such as myself.
Help to better educate anglers on identifying sharks. Many look similar and knowing what I could harvest vs what I cannot would be helpful.
Educate - assure shark identification and proper fishing techniques.
I don't fish for sharks as a habit, as they're mostly caught as a result of general fishing. I respect all sea creatures and try and return them in the safest manner possible. I believe shark identification would go a long way to help ease the problem.
Educate anglers, send me info to pass on to my 4,000 angler friends.
Better pictures for shark identification.
All anglers should have NOAA shark tags for shark release that way species can be tracked.
Educate the public; make identification guides readily available (i.e. maybe a sign at surf fishing crossings).
An education guide for anglers when they fish in Delaware, about our common sharks and how to deal with them.
Conservationist visiting the beaches and educating fisherman about best practices and proper gear.
Education.
Get more anglers in on the tagging programs, provide more information, better information, and make it easy to access.
Education on responsible catch and release techniques.

Responses to "Do you have any suggestions for changes to shark management that will enhance the conservation of shark species?" Responses are categorized from 93 recreational anglers in the Mid-Atlantic region; margin of error is 9%.

Education and training
Shark fishing license with training in handling of sharks and identification of species.
Publicize and document rational for regulations.Currently the explanations are non-existent or overly complex. I should not need to spend hours reading synopsis of research that belongs in scholarly publications.
More information in public fishing grounds for the public.
Angler education.
Better education on identifying shark species.
Give every angler a shark identification guide with their license purchase.
Better education for recreational anglers, shark permits that can only be received by taking an online class or class hosted by the state at Lewes UD.
Anglers need more education how to identify different species of sharks to comply with regulations.
Angler education. Knowledge brought forward to them. Awards/acknowledgment given to conservation and release.
Need more public information about these issues!
Education on why conservation is needed.
Education of anglers.
Education. I did not realize there was an issue.
More public outreach, instead of more regulations, a few land based fisherman showing off ruin it for everyone plus the general public sees beach shearling as attracting dangerous predators which is not the case, those sharks are always there.
Give detailed pictures and descriptions of all shark species. Extremely hard to accurately identify with any kind of efficiency so that a prohibited species may be released so that it survives. Half the time a shark dies before it can even be identified especially for inexperienced anglers.
I think education on proper techniques and awareness need to be put into place more commonly than more restrictions.
Changes to current regulations/proposed new regulations
Do not allow shark fishing on public piers and on all boats
Only use circle hooks
Ban long lining and finning at sea
Stop specifically targeting inshore species of sharks for catch & release
No kayaking off the beach for sharks
Bottom trawling needs to be outlawed!!!! Need stronger restrictions on menhaden by the commercial fishery.
Prohibit kayaking bait. I don't target sharks but catch them occasionally from the surf, mostly dogs and [S]andbar.

Responses to “Do you have any suggestions for changes to shark management that will enhance the conservation of shark species?” Responses are categorized from 93 recreational anglers in the Mid-Atlantic region; margin of error is 9%.

Changes to current regulations/proposed new regulations
Change the in-the-water requirement for handling and release.
Use hooks that will rust out (not stainless steel).
Make it illegal to chum from the beach.
Dropping a hook attached to a pole on land by kayak then fishing from shore with a pole should be illegal.
Stop the throwing chum items off charter boats and help with fish gutting in inland.
Reduce longlining.
I don't believe restricting the method of deploying a bait is a fair to the anglers who are shark fishing.
Stop the law about taking out of water. You don't think shark die from having leaders left in their mouth/gut?
Ease up on [S]andbar shark restrictions, I catch them every trip almost.
Yes I believe for the sharks safety and all fishermen's safety we should be able to bring the sharks out of the water and get hooks and leader out I personally don't like to leave the leader line and hooks in their mouth I feel that they don't rust right out and question 17 I didn't understand I just filled out to be done with the survey I think this would be good to talk about this at a meeting so people know what this is saying thanks have a great day.
Unreasonable rules like wading into the surf with a large shark to release it discredit the entire conservation effort. Have reasonable and understandable rules that make sense.
I understand that you don't want the sharks out of the water but to fine someone for taking the shark out of the water in attempt to remove the hook seems a bit excessive. I don't target sharks but I do catch them when fishing for other species. I don't even know what type of shark I have until I pull it out of the water. Since I don't want to get fined, I just cut my line if I think the shark is anything but a dogfish. That can't be good for the shark.
Allow harvest of [S]andbar sharks.
Allow us to bring farther out of surf to be able to get hook out of mouth safer and with less harm and time to angler and shark.
Don't allow targeting of sharks during certain times, educate anglers on shark ID, enforce regulations better.
Provide more evidence and PR that prove that keeping the shark in the water when releasing is effective. No other surf fishing beaches have this mandate, if they do it is not enforced. This is risky business and when someone gets hurt in DE - it will be a headline that reads "because DE said I had to." Not good business without the proof.
We try to always release sharks in the water. It would be nice to know that if by some chance or reason you absolutely have to bring a shark out of the water you wouldn't get in trouble. I mean only emergency reasons.
Only allow legal catching of sharks from charter boats.
No need to catch sharks. Preclude it by statute.
Limit size for catch and designate no fishing zones.

Responses to "Do you have any suggestions for changes to shark management that will enhance the conservation of shark species?" Responses are categorized from 93 recreational anglers in the Mid-Atlantic region; margin of error is 9%.

Enforcement
Better policing on surf fishing side. Seen too many get manhandled and likely to die.
Increase fines. Fine anyone targeting restricted species. It is obvious what you will catch from the beach. Restricted species. People are just cutting them off.
Apply licensing fees specifically for shark anglers, prohibit the landing, handling, and targeting of ALL species to those who have not paid an additional fee for shark fishing. Real shark anglers would be willing to pay an additional fee. Personally $100.00 or more I think would be great. It will deter inexperienced folks from targeting sharks. Mandatory jail time and hefty fees for breaking the law. Don't keep folks who are passionate about the sport out of it because others pose a threat to sharks.
Stronger penalties for keeping under sizes or prohibited sharks. I'm talking financially crippling fines.
Heavier restrictions/fines on commercial fishing for shark fatalities & methods.
Enforcement of existing regulations.
Don't allow targeting of sharks during certain times, educate anglers on shark ID, enforce regulations better.
Commercial fishing
Limit commercial fishing so they don't accidentally kill sharks.
Close the recreation & commercial gill net fisheries as those areas in the Delaware bay are where the sharks pup.
Focus on commercial fishing.
Restrict recreational shark fishing and increased restrictions on commercial.
Regulate commercial fisheries. Netting kills sharks, recreational anglers pose very little risk to shark populations. Pollution and commercial overfishing are the gravest threats to sharks.
More commercial/ less recreation restrictions (size & bag limits).
Think what's in place for recs ok need more restriction on longliners and finners with more enforcement dollars.
Enforcing International commercial fishery restrictions and heavier sanctions. Although I do not approve of these recreations fisherman that target sharks, they are a drop in the bucket compared to foreign commercial fisheries.
Other comments
Research and treat it as if they will migrate more rapidly sometime soon. Need no for incidents from the shore for motivation. Global warming effects will increase the natural desire for a consistent/reliable food sources. You're dealing with the top of the food chain (water-lion), don't underestimate nor undermine its capabilities.
Help stop pollution and fight finning. Habitat conservation and species preservation must continue to take place.
No reason to shark fish other than Mako and Thresher.
Don't eat shark fin soup.

Responses to “Do you have any suggestions for changes to shark management that will enhance the conservation of shark species?” Responses are categorized from 93 recreational anglers in the Mid-Atlantic region; margin of error is 9%.

Other comments
No, never have targeted them, but many are fun to catch when I do hook them. Always release, hook out when at all possible!
Unsure of the current regulations, other than catch limits and restricted species so perhaps you should include those or a link to them. Looked at the DNREC site but did not spot much other than what I previously mentioned. Also you have problems with your survey. First, make a field like this larger. Second, let us know what the character limit is and how to rank the options in question 17. Is 1 a most willing or is 7? Not sure how valid my answers are, just trying to help. Will assume a 1 is most willing and a 7 is least willing to adopt said measure. As for a conservation suggestion, if it is not already illegal finning should be.
That's a tough one. Myself and the guys I fish with are all very experienced with regards to shark fishing. We can have a shark unhooked, photo, tagged, and released in 30-60 seconds. There are many out there that have no idea what they are doing and therefor put the Sharks at risk. It's tough for me to sign off on more restrictions because it may limit my ability to enjoy a sport I love, but it may be necessary.
I like Delaware’s regulations need more states to fall in line. We have to [be] on our game to release them in the water.
Don’t let idiots fish for them.
Listen to the experts.
Although it sounds good on paper, I don't fish for sharks! If I catch one, I release it as quickly as possible. It is only those who regularly fish for sharks that abuse them. Most people feel they are a nuisance fish and just toss them back.
I really do not target shark other than one trip every spring with a seasoned shark fisherman, but I think it is gaining popularity and too many novices will hurt the species.