AQUATIC CONSERVATION: MARINE AND FRESHWATER ECOSYSTEMS

Aquatic Conserv: Mar. Freshw. Ecosyst. **26**: 689–702 (2016)

Published online 21 December 2015 in Wiley Online Library
(wileyonlinelibrary.com). DOI: 10.1002/aqc.2581

Catching sharks: recreational saltwater angler behaviours and attitudes regarding shark encounters and conservation

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ABSTRACT

1. With the increasing popularity of recreational angling around the world, there is a need to better understand the potential contribution of recreational fishing to reported shark population declines. However, the nature and perception of shark encounters – a fundamental precursor to future research, management and conservation measures aimed to increase shark survival – is not well documented in recreational fisheries.

2. Five hundred and ninety recreational saltwater anglers responded to the survey and reported their experiences targeting or incidentally catching sharks, as well as their attitudes toward sharks, shark fishing techniques, and shark conservation and management.

3. The survey found sharks were caught regularly, with 57% of respondents commonly targeting sharks and 93% of respondents having caught a shark at least once. Eighty-eight percent of the respondents released the last shark that they caught and most respondents often or always practised catch-and-release when catching sharks.

4. The survey revealed that avid anglers have positive attitudes toward sharks and shark conservation and have a desire to handle and release sharks in ways that will increase their likelihood of survival.

5. However, the survey also revealed that there are a variety of situational factors (e.g. target fish, fishing platform) that influence the choices that anglers make while fishing, which may influence adherence to catch-and-release methods.

6. Based on their positive attitudes toward sharks, recreational anglers may be strong allies for the development, dissemination, and adoption of species and situational-specific best practice catch-and-release guidelines for this group of fishes within the wider recreational saltwater angling community.

Received 5 November 2014; Revised 8 April 2015; Accepted 13 June 2015

KEY WORDS: coastal; ocean; survey; public perception; fish; fishing; recreation

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INTRODUCTION

Worldwide, many chondrichthyan (elasmobranchs and holocephalans) populations are in reported decline, with roughly one in four species designated by the IUCN Red List as threatened owing to overfishing (Dulvy *et al.*, 2014). It has been widely held to date that commercial fisheries are chiefly responsible for reported declines in elasmobranch (shark, ray and skate) populations (Stevens *et al.*, 2000; Fowler *et al.*, 2005; Dulvy *et al.*, 2014); however, the popularity of recreational fishing is growing, with an estimated 10.5% of the world's population participating in recreational angling (Cooke and Cowx, 2004; Arlinghaus and Cooke, 2008). In 2012, it was estimated that 11 million anglers made more than 72 million saltwater fishing trips in the United States (NMFS, 2014a). As such, it is not surprising that recreational fisheries are increasingly thought to contribute to declining fish stocks, perhaps even exerting more pressure than commercial fisheries for some species (Coleman *et al.*, 2004; Cooke and Cowx, 2006; Lewin *et al.*, 2006).

Some recreational anglers target sharks, but sharks are also caught incidentally as bycatch, and in both instances sharks are often released. In the United States, recreational anglers caught an estimated 4.1 million sharks and 1.66 million dogfish in 2012 and released 96% of sharks and 97% of dogfish (NMFS, 2014a, b). The effects of physical trauma and physiological stress on captured and released sharks vary with the capture and handling methods involved (Skomal, 2007), and the gear and methods recreational anglers use may play a significant role in fish survivorship (Cooke and Suski, 2005; Danylchuk *et al.*, 2007). For example, factors such as hook type, time required to land, and exposure to air all determine the animal's condition upon release (Borucinska *et al.*, 2001, 2002; Cooke and Suski, 2005; Brill *et al.*, 2008; Cicia *et al.*, 2012; Kneebone *et al.*, 2013; Danylchuk *et al.*, 2014). Species-specific differences in sensitivity to capture by hook and line fishing gears suggest that evolutionary, anatomical/physiological, and/or ecological factors may hold influence on whether a given shark species survives (Morgan and Burgess, 2007; Mandelman and Skomal, 2009; Gallagher *et al.*, 2014). Despite this heightened attention to shark survival, very few studies (e.g. blue sharks, Campana *et al.*, 2006 and sharpnose sharks, Gurshin and Szedlmayer, 2004) have evaluated the impact of recreational angling on elasmobranch populations and the most commonly employed catch-and-release practices for sharks in recreational fisheries are not yet well understood. Before developing specific guidelines for shark capture and release angling, it is important to evaluate how recreational anglers presently perceive the capture of sharks and to identify which capture and handling practices are currently used.

The choices that recreational anglers make about fishing are influenced by a variety of complex attitudes, beliefs, knowledge, and norms (Arlinghaus *et al.*, 2007), including cultural and social dynamics (Arlinghaus *et al.*, 2007), situational factors (Sutton, 2001), their experience and skill (Oh and Ditton, 2006), and their level of commitment to fishing (Buchanan, 1985). There are specific reasons that anglers practise catch-and-release fishing related to their experience and behaviour. Recreational anglers catch-and-release fish for a number of reasons, including management (e.g. prohibited species or size or bag limits), because the fish are viewed as bycatch, or for ethical or conservation considerations. In many cases, an angler may practise catch-and-release voluntarily because they assume that a fish released alive will survive to be caught again (Quinn, 1996; Aas *et al.*, 2002). Sutton (2001) suggested that committed anglers (i.e. those with a high level of experience who rate fishing as a central part of their lifestyle) who target big game fish with well-publicized conservation issues, may see a greater need to practise catch-and-release to ensure their future fishing opportunities than anglers who target healthier fish stocks. However, while anglers may be supportive of conservation practices, many are opposed to regulations that restrict their own habits (McClenachan, 2013). Tournament and trophy fishing is one area that may prevent an angler from releasing their catch (Shiffman *et al.*, 2015), but these competitions have moved toward higher rates of catch-and-release (Schratwieser 2015).

Recreational anglers may also have specific perceptions about sharks that influence if and how they catch sharks. Research has shown that attitudes about sharks may be influenced by

demographics (e.g. age, gender, income, ethnicity, education) (Kellert and Berry, 1980), participation in wildlife activities or first hand encounters (Dobson, 2007), and most importantly, knowledge (Thompson and Mintzes, 2002; Friedrich *et al.*, 2014). Public perception of sharks has transitioned from the 1970s: 'humans need protection from sharks' to the 2000s: 'sharks need protection from humans' (Dearden *et al.*, 2008; Whatmough *et al.*, 2011); over the same time period, recreational shark fishing has progressed from predominately consumptive to almost entirely catch-and-release (Dobson, 2008). Recognition of decreases in shark populations owing to human activities (Dulvy *et al.*, 2008), and greater scientific understanding of the role of sharks in the ocean ecosystem (Stevens *et al.*, 2000) may have contributed to changes in perception and the current, more conservation-based approach to catching sharks (Simpfendorfer *et al.*, 2011). Although people have become more aware of the threats sharks face, an analysis of media portrayal of sharks in the United States found that coverage still emphasized shark attacks and the risks sharks pose to people (Muter *et al.*, 2012) and, on an institutional level, sharks are still not a high priority in comparison with other fisheries (Jacques, 2010). It is often assumed that individuals participating in outdoor recreational activities, such as angling, are more likely to support conservation; however, recreational specialization and activity-specific preferences may have the largest role in predicting conservation attitudes and behaviours (Oh and Ditton, 2008). It is important to understand the reasons individuals practise catch-and-release of sharks to improve both the biological science of fisheries management and to enable dialogue between anglers, managers, scientists, and other stakeholders (Arlinghaus, 2005; Simpfendorfer *et al.*, 2011).

Study aims

This study aimed to identify recreational angler catch of sharks, fishing behaviours, and attitudes towards shark fishing and conservation across the United States. A questionnaire was employed to: (1) document which sharks are caught, where and through which types of fishing; (2) identify patterns in capture, handling practices, and release techniques among recreational anglers; (3) assess attitudes of recreational anglers towards catching sharks and shark conservation measures; and (4) examine the relationships between fishing behaviour and attitudes.

METHODS

Survey planning

This survey aimed to reach a cross-section of recreational saltwater anglers from across the United States. Seven saltwater anglers from around the United States, who had participated in saltwater and shark fishing at varying intensities, completed a pilot version of the questionnaire and provided feedback that was incorporated before launching the survey. The survey was hosted by Survey Monkey (Palo Alto, CA, USA) and was active from April to October 2013 (Appendix S1, Supplementary material).

The survey was distributed using a purposive snowball-style method (Penrod *et al.*, 2003) because it enabled us to identify and reach a group of diffuse respondents that would otherwise be difficult to encounter (Goodman, 2011). Snowball internet surveys that exploit social media and stakeholder fora have been used for fisheries science research (Hasler *et al.*, 2011), hospitality and tourism research (Wolfe *et al.*, 2014), and various social issues such as those related to gender and sexuality (Wall, 2013). Although purposive snowball-style internet surveys have a number of advantages over conventional survey designs, they also have important limitations (Fricker and Schonlau, 2002, Beidernikl and Kerschbaumer, 2007), notably the non-random sampling-based survey design precludes generalized insights. For this study, key figures in recreational angling organizations were identified and asked to distribute the survey to their members and associates active in the recreational angling community. The survey was posted on the International Game Fish Association (IGFA) website, which boasts thousands of members in the United States. Other individuals and organizations used the link on the

IGFA announcement to repost the survey on social media platforms (e.g. Facebook, Twitter), which were tracked during the distribution period. The survey was also announced through online recreational fishing newsletters and magazines (e.g. The Fisherman). A short description with a link to the survey and contact information for the research team, were also posted on numerous recreational fishing forums (e.g. SportFishing.com, bigfishtackle.com, etc.). On each site, the survey information was posted under multiple discussion boards, such as those targeting specific regions of the United States (e.g. eastern seaboard, California, Gulf Coast) and specific recreational fishing topics (e.g. shark fishing, coastal, offshore, kayak). The questionnaire was anonymous and all responses were voluntary. Access to the survey was restricted to one response per computer to limit bias due to repeated responses by individuals.

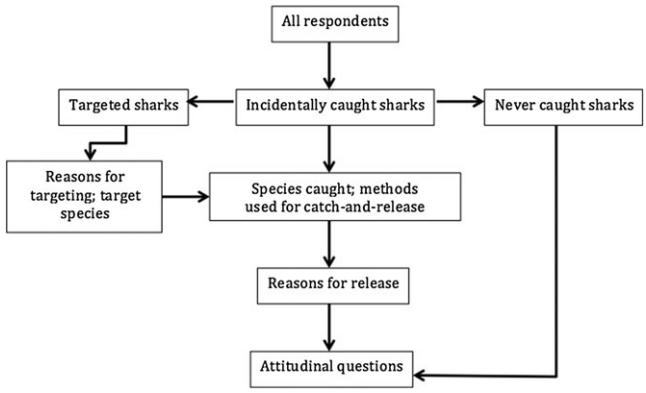

Figure 1. A branching survey was created to collect responses from recreational anglers that target sharks, those that have caught sharks incidentally, and anglers that have never caught sharks. Based on that characterization, respondents were asked questions about their fishing behaviour and attitudes toward sharks and shark conservation.

Survey design

The questionnaire comprised five sections: the importance of recreational fishing to the individual; shark fishing; shark handling and release practices; attitudes toward sharks and shark conservation; and demographic information. The questionnaire used branching logic to separate respondents who targeted sharks (i.e. fished with the goal of catching a shark), those who had caught sharks but did not target them, and individuals that had never caught a shark (Figure 1). In the first section, all respondents were asked to answer questions about professional qualifications, the number of years they had been fishing, number of days they fish each year, and how fishing ranked as part of their lifestyle (ranging from least important to most important). In the second section, they were asked if they had ever targeted sharks. If they answered 'yes', they reported what species they targeted and the reasons they targeted sharks. If the respondent answered 'no', they were asked if they had ever incidentally caught a shark while fishing. If the respondent had never caught a shark, they were skipped to section four. If the respondent had caught a shark (either target or bycatch), they were directed to the third section of questions, which asked them to describe the details of their most recent shark catch, including: location (geographic, water body, fishing site, or platform), gear used (hook, bait, lure, line, and pole), shark handling behaviour (length of landing, health status, hook location, if and how long the shark was out of the water, and if it was tagged, measured, or weighed, and if the hook was removed). If the respondent released the shark, they were asked to describe measures taken to revive the shark, health status, and the reasons for release. Section four asked respondents about their attitude towards sharks using questions adapted from Lynch *et al.* (2010) – a survey focused on shark anglers in the Great Barrier Reef region of Australia. Respondents were asked to rate their agreement with statements using a Likert scale (with 1 = strongly agree, 2 = somewhat agree, 3 = neither agree nor disagree (neutral), 4 = somewhat disagree, and 5 = strongly disagree). Respondents were also able to provide optional comments on each of these questions.

The fishing experience of respondents was hypothesized to be a relationship between number of years fished, number of days fished per year, how important the respondent rated fishing as part of their lifestyle and whether the respondent had professional angling experience. A PCA analysis was conducted to determine if these variables could be reduced, but they were not linearly related ($KMO < 0.8$), so they were analysed individually.

The attitude questions were grouped to measure beliefs on four different domains: (1) value of catching a shark; (2) importance of releasing sharks in good condition; (3) understanding of threats to sharks; and (4) the existence value of sharks. The statements in each domain were summed to calculate a separate index for each domain. Negative statements were reverse coded. A Cronbach's alpha reliability coefficient was calculated for each domain, where $\alpha > 0.7$ indicated an acceptable level of reliability (DeVellis, 2003; Kline, 2005). Relationships between the attitudinal domains, fishing locations, and angler behaviours were analysed using the Pearson's chi-square goodness of fit statistic. Statistical significance was set at 0.05. All statistical analyses were performed using SPSS software (IBM, 2011).

RESULTS

Respondent demographics

In total, 590 recreational anglers completed the survey over a seven-month period. Ninety-eight percent of the respondents were men, 73% were more than 30 years old. Nearly 60% of respondents reported holding a college degree or higher.

The majority of respondents were avid anglers, participating frequently in the sport and/or placing a high degree of importance on it as part of their lifestyle. Fifteen percent of respondents reported being employed as charter boat captains or had similar professional experience. Respondents had a wide range of fishing experience ranging from less than 1 year to 75 years; the average number of years fishing was 29. The average number of days fished per year was 75, but the most common (modal) number of days reported was 30. Forty-six percent of the respondents ranked fishing as the most important part of their lifestyle. The high participation rates and comments related to these questions revealed very strong preferences for recreational fishing; one respondent replied: 'it is not just a hobby it is a lifestyle and is who I am [sic]'.

The majority of respondents fished in the north-east region of the United States (44%), with slightly fewer fishing in the Gulf of Mexico (26%) and the south-east (12.7%) and very few in the south-west (7.1%), north-west (3.3%), the Caribbean (3.1%), the Pacific Islands (2.2%), and elsewhere (0.9%).

Catch information

Respondents presented different fishing interactions: over half of the anglers (57%) reported targeting sharks while the remainder (43%) only caught sharks as bycatch. Forty-seven percent of those did so infrequently, less than five times per year, while fishing an average of 28 days per year. The main reasons respondents gave for targeting sharks were 'sport/fun'; 'fight'; 'food'; 'size/strength/power'; and 'thrill/apex predator'. Respondents also mentioned interest and respect for the animal, wanting to educate or impress people, that sharks were inexpensive to catch ('poor man's big game fishing') or more readily available than other fish, tournaments, research, and occupations as reasons for targeting sharks. Respondents reported targeting 28 species of shark (Table 1). Although the specificity in responses implies that the respondents know and are properly identifying the species they catch, it is very possible that there are cases of mistaken identification (Mallison and

Table 1. Counts of the sharks targeted by respondents that fish for sharks

Species	Count	Species	Count
Blacktip	115	Any	32
Mako, unspecified	115	Porbeagle	21
Bull	92	Bonnethead	18
Thresher[a], unspecified	83	Sand tiger	16
Sandbar*	58	Dogfish[b], unspecified	12
Blue	54	Leopard	11
Lemon	50	Atlantic sharpnose	11
Hammerhead[c], unspecified	50	Dusky*	9
Tiger	44	Caribbean reef*	7
Spinner	33		
Five or less: Seven-gill*, soupfin, nurse, brown smoothhound, bronze whaler, salmon, white*, silky*, Galapagos*, and blacknose			

[a]Most likely common
[b]Spiny dogfish 6, dogfish 5, smooth dogfish 1
[c]Hammerhead 47, great/greater hammerhead 2, scalloped hammerhead 1
*Federally prohibited species

Cichra, 2004; Page *et al.*, 2012) especially with congeneric species of the genus *Cacharhinus*, several of which are difficult to distinguish from one another depending on life stage (Compagno, 1984).

Ninety-three percent of respondents had caught a shark at least once while fishing. Although respondents were only asked to recall their most recent shark catch, most reported more than one shark species, so the total count is greater than the number of respondents (Table 2). Naturally, the last species of shark reported caught reflects the region in which the angler was fishing. The piked (i.e. spiny) dogfish, *Squalus acanthias*, and the, dusky smoothound, *Mustelus canis* (both hereafter referred to as 'dogfish'), were the most commonly reported and, 84% were caught in the north-east. Eighty-five percent of the blacktip sharks, *Carcharhinus limbatus*, reported were caught in the south-east and Gulf of Mexico. In general, a much greater variety of sharks were caught in the south-east and Gulf of Mexico than in other regions.

Comparing the list of sharks respondents targeted with the list of sharks caught most recently, suggests that dogfish sharks are nearly always caught as bycatch. Only 12 respondents said that they targeted dogfish while 137 reported them as the last species caught. It is possible that anglers may behave differently when catching, handling, and releasing an unwanted bycatch species than they would with a species they are targeting. To examine this, the relationships between behaviour and attitudes of the respondents who reported catching dogfish and blacktip sharks as their last catch were compared (Table 3).

Table 2. Counts of the last shark(s) caught by respondents who targeted or incidentally caught sharks. Sharks were identified to the species if possible

Species	Count	Species	Count
Dogfish[a], unspecified	137	Bonnethead	22
Blacktip	107	Atlantic sharpnose	20
Blue	77	Leopard	18
Mako[b], unspecified	64	Caribbean reef*	14
Bull	46	Spinner	14
Sandbar*	40	Nurse	13
Thresher	30	Porbeagle	12
Hammerhead, unspecified	26	Unknown	10
Lemon	24	Dusky*	8
Tiger	22		
Five or less: Sandtiger, white tip, white, seven-gill*, Galapagos*, silky*, salmon, swell, sawfish*, horn, smoothhound, angel, basking*, soupfin, finetooth, sixgill*			

[a]Dogfish 93, spiny dogfish 30, smooth dogfish 14
[b]Mako 58, shortfin mako 6
*Federally prohibited species

Fishing methods

A similar number of respondents caught sharks offshore (42%) compared with those who caught

Table 3. Respondents' behaviours and attitudes based on their last shark catch (dogfish spp. = bycatch, blacktip = target, other spp. = all other sharks caught)

	Dogfish spp.	Blacktip	Other spp.	p-value
Behaviour				
Do you target sharks? Yes	33%	75%	68%	0.000
Interest in bycatch reduction techniques? Yes	67%	29%	47%	0.000
Type of water body?	Offshore 54%	Coastal 86%	Offshore/coastal 48%/52%	0.000
Fishing platform?	Boat 85%	Shore 60%	Boat 70%	0.000
Hook type? Circle	38%	77%	60%	0.000
Fight time?	< 5 min 76%	6–20 min 51%	6–20 min 43%	0.000
Hook location? Mouth	90%	97%	90%	0.160
Blood around gills? No	87%	93%	91%	0.318
Released? Yes	95%	92%	84%	0.004
Was it taken out of the water? Yes	87%	52%	36%	0.000
How long was it out of the water?	< 1 min 60%	1–5 min 66%	1–5 min 61%	0.002
Measured? Yes	5%	52%	53%	0.000
Weighed? Yes	3%	4%	4%	0.799
Tagged? Yes	2%	15%	9%	0.011
Hook removed? Yes	92%	74%	66%	0.000
Measures taken to revive? Yes	5%	27%	12%	0.000
Attitude domains				
Value of catching sharks	Disagree 51%	Agree 65%	Agree 60%	0.000
Importance of releasing sharks in good condition	Agree 85%	Agree 95%	Agree 95%	0.010
Managing threats to sharks	Neutral 40%	Neutral 41%	Neutral 44%	0.492
Value of sharks to their ecosystem	Agree 91%	Agree 97%	Agree 96%	0.184

sharks in coastal water bodies (58%). Sharks were most often caught from personal boats (45%) and from the beach (33%). They were less frequently caught from charter boats (contracted boat carrying less than 10 people) (15%) and headboats (large party boat carrying between 10 and 100+ people) (7%). Of the respondents that described their hooks, 31% reported using circle hooks and 20% J hooks. A few respondents voluntarily commented on using non-stainless steel, degradable hooks, while others were adamant about not using circle hooks. The size of hooks used varied greatly, from 1/0 to 20/0. Natural bait was used (85%) more often than artificial bait (14%). Hook choice and size and bait type were likely functions of target catch species and body size.

Subsequent survey questions asked those anglers who released sharks to describe handling and release methods. For the 88% of respondents who released the last shark they caught, landing times ranged from less than 1 min to more than 60 min, with 1–5 min being the most common (32%). Anglers reported nearly all sharks were hooked in the mouth or surrounding area (92%); only 3% were gut hooked. Respondents were more likely to remove the hook (75%) than leave it in (25%). Those who fished from private boats were also more likely to leave the hook in (39%) than those fishing from shore (11%) or from a charter or headboat (21%) ($P < 0.01$). Those respondents who reported leaving the hook in the shark were asked to report how much line remained. Respondents reported cutting the line and leaving anywhere from an inch to 5 feet of line on the hook. A few of the respondents who reported leaving the hook in said the decision to do so was motivated by wanting to release the shark as quickly as possible to ensure survival. For example: 'I have seen sharks die because the fisherman took too long to remove the hook. This is especially true with greater hammerhead sharks…They like to fish to the death and will not survive if they aren't released very quickly.' Over half of the respondents took the shark out of the water. Shore based respondents were more likely to take the shark out of the water (i.e. beach dragging; 67%) than those fishing from a private boat (37.9%) ($P < 0.01$). Respondents who did take the shark out of the water reported that they did so for less than a minute (45%) or between 1 and 5 min (54%). Very few respondents said they needed to take additional measures to revive the shark (14%).

Reasons for release

Four hundred and seventeen respondents gave one or more reasons for releasing the last shark they caught. Many respondents (43%) said that catching the shark was unintentional (bycatch) and 38% said that they always practise catch-and-release when they fish for sharks. Other explanations for releasing (i.e. not targeting) sharks included the notion that the meat is inedible (23.5%) and the sharks lack 'value' (23%). Individuals also mentioned the need to comply with policy/regulations (e.g. protected species, undersized, cryptic species identification) and the desire to promote conservation (e.g. sharks are endangered, they are important for the marine environment, tagging for research). Only one person cited their own safety as the reason for releasing sharks.

Attitudinal responses

Respondents overwhelmingly agreed with statements about the importance of releasing sharks in good condition (89%), including understanding that their own fishing behaviours influenced the survival of the shark (88%) and that they would be willing to use tackle and special handling techniques to minimize damage to sharks (80%) (Table 4). The respondents also had extremely positive beliefs regarding the value of sharks to ecosystems (86% agreement). Respondents agreed with statements about the importance of having viable populations of sharks (95%), agreed that sharks are signs of a healthy ecosystem (92%), and that they enjoy seeing sharks in the ocean (86%).

There was less agreement among respondents regarding statements about management to protect sharks. Respondents were divided over whether more regulations on recreational fishing are needed (36% disagree, 29% neutral, and 35% agree) and whether recreational fishing affects the health of sharks (38% disagree, 23% neutral, and 39%

Table 4. Recreational anglers' responses to belief statements about catching, releasing, threats to, and existence value of sharks. Attitude measured from 1 = strongly agree to 5 = strongly disagree. Strongly agree and somewhat agree have been grouped as well as strongly disagree and somewhat disagree. The survey questions were adapted from Lynch *et al*. (2010)

Attitude domains and statements	Disagree %	Neutral %	Agree %
Value of catching a shark (α = 0.768)	48	19	43
Catching a shark adds to the enjoyment of my fishing trip	21	15	64
I prefer to catch fish other than sharks[a]	9	23	68
Sharks are good to eat	32	25	43
I enjoy the challenge of catching a shark	19	17	64
Catching a shark is a waste of my fishing time[a]	62	16	22
I target sharks when I go fishing	41	18	41
Sharks are a threat to other fish I want to catch[a]	64	18	18
Importance of releasing a shark in good condition (α = 0.750)	4	7	89
I like to ensure that a shark is released in good condition	2	6	92
It does not matter to me whether a shark survives after I release it[a]	89	3	8
The survival of a shark depends on how I release it	4	8	88
I would be willing to use tackle and special handling practices to minimize damage to released sharks and to improve their chance of survival	7	13	80
It is important that all fish I release survive	3	3	94
Managing threats to sharks (α = 0.726)	30	20	50
More regulations are required for recreational fishing of sharks	36	29	35
Recreational fishing does not affect the health of shark populations[a]	38	23	39
Commercial fishing is a threat to shark populations	5	9	86
Recreational fishing is a threat to shark populations	54	23	23
Sharks need to be protected	16	16	68
Value of sharks to ecosystems (α = 0.722)	6	8	86
It is important to have viable populations of sharks	1	4	95
It would be better if there were fewer sharks in the ocean[a]	87	8	5
Sharks are of little use or importance to humans[a]	81	11	8
Sharks are a threat to humans[a]	83	9	8
Sharks are a sign of a healthy ecosystem	2	6	92
I enjoy seeing sharks in the ocean	5	9	86
Sharks are an irrelevant part of the ocean ecosystem[a]	88	4	8
Sharks should be conserved because they have the right to exist	9	16	75

[a]Items reverse coded for calculation of overall score.

agree). They were in agreement, however, about the threat of commercial fishing to sharks (86%) and most agreed that sharks need to be protected (68%). Respondents were also divided over the value of catching sharks. Although most (64%) said that they enjoy catching sharks and that it adds to the enjoyment of their fishing trips, 68% reported that they would rather catch other fish.

Attitudinal responses and fishing experience and techniques

There was no relationship between how important respondents rated fishing as part of their lifestyle or whether the respondent had professional experience with the attitudinal domains. The number of years fished and days fished per year were only related to how the respondent valued catching sharks.

The value placed on catching sharks appears to differ by region of fishing ($P < 0.01$), with respondents in the Gulf of Mexico in strong agreement (69%) on placing high value, versus more neutral (21%) and disagreeing (32%) responses in the north-east. Agreement with management to protect sharks also differed significantly ($P = 0.034$), with respondents from the Gulf of Mexico more neutral (46%) or in disagreement (24%). The value of catching sharks was also significantly related to the type of fishing location ($P < 0.01$), with shore-based respondents having a higher agreement (75%) than those fishing from charter or headboats (33%) or a personal boat (47%). Similarly, respondents that fished from shore were located mainly in the south-east or Gulf of Mexico, while respondents in the north-east fished from private boats.

As expected, the value placed on catching sharks was related to whether the respondent targeted sharks ($P < 0.001$), with those that target sharks strongly agreeing (80%) with the value of catching

sharks more than those that did not target sharks (8%); the more they fished for sharks, the more they valued catching sharks ($P < 0.001$). More respondents who agreed with the importance of releasing sharks in good condition also agreed that there was value in catching sharks ($P < 0.001$). There was also a significant relationship between fishing interaction type and the level of agreement with shark protection management measures ($P = 0.007$), with respondents that targeted sharks mostly neutral to statements about management (45%) and those that did not target sharks in agreement with management (52%). The less often the respondent fished for sharks, the greater their agreement was with the shark conservation management ($P = 0.010$). Respondents that were interested in bycatch reduction techniques also had greater agreement with shark conservation management (52%) than those that were not interested (34%) ($P < 0.001$).

There were no significant relationships between tackle choices and the attitudinal domains. How long it took to land the shark, however, was significantly related to how much the respondent valued catching sharks. For example, respondents that did not value catching sharks reported shorter fight times (42%) than respondents that did value catching sharks (65%) ($P < 0.01$). Seventy-seven percent of respondents that revived sharks valued catching them, while 46% of respondents that did not revive the shark valued catching them ($P = 0.001$). Respondents that took measures to revive the shark also agreed with the importance of releasing sharks in good condition 100% of the time.

DISCUSSION

This survey was intended to elicit insights, attitudes and behaviours regarding sharks among US recreational anglers across a broad geographic range. Results from the study suggest that sharks are caught regularly among these respondents, even by those not targeting sharks. Respondents released 89% of the last sharks that they caught (84% of the targeted sharks and 95% of the incidentally caught). Most of the respondents indicated that they often or always release sharks and other fish that they catch. The high release rates found by this survey and others (Lynch *et al.*, 2010; NMFS, 2014) may be explained, in large part, by anglers releasing incidental catch and to a lesser extent, regulatory releases. Since sharks are regularly incidentally caught by anglers, we may assume that some anglers in this situation may not have the knowledge or gear to follow best catch-and-release practices.

The results of this survey indicate that avid recreational saltwater anglers surveyed here had positive attitudes toward sharks and value shark survival and conservation. They overwhelmingly agreed with statements about releasing sharks in good condition and ensuring their survival. Respondents also agreed strongly with statements about the importance of having healthy shark populations. These responses are similar to those from charter boat captains in Florida regarding the importance of shark conservation and catch-and-release practices when shark fishing (Shiffman and Hammerschlag, 2014) and to recreational saltwater anglers fishing on the Great Barrier Reef (Lynch *et al.*, 2010). While respondents valued sharks, many respondents placed a lower value on catching sharks than other fish. This finding supports the arguments that some recreational anglers have moved away from consumption-based motivations for catching sharks and also that participants are more knowledgeable about the importance of sharks to the marine ecosystem and the threats they face.

Despite the positive attitudes among respondents, angler behaviours were not necessarily promoting high probability for the survival of released sharks. The National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS) Apex Predators Program has published guidelines aimed to maximize shark post-release survival (nefsc.noaa.gov/nefsc/Narragansett/sharks/survive.html). NMFS recommends that recreational anglers who catch-and-release sharks: (1) use non-offset circle hooks; (2) set the hook immediately in the lip or jaw to avoid gut hooking; (3) reduce fight times by using heavy tackle; (4) minimize handling of the animal, including not landing the shark; (5) use a dehooker to remove the hook; and (6) revive the shark if it is fatigued or near death. Despite the claims from respondents that nearly all

sharks were released in good condition, there was inconsistent adherence to these recommendations. Even though the NMFS guidelines were not always met, the responses and comments indicate that respondents still perceive that they are taking actions to increase the likelihood of shark survival. Respondents specifically stated that they believed that a long fight time was a threat to shark survival and that they took measures to reduce fight times. For example, one respondent wrote, 'anything over 30 min and the shark does not stand a chance to survive.' Another opined that 'big gear lands shark quickly, doesn't fatigue them and that is why I use it [sic]'. Other comments from the respondents indicate that removing the hook is only done in some circumstances, that angler safety is a consideration, and some believe that trying to remove the hook can stress the shark unnecessarily.

Angler attitudes and behaviours differed according to fishing interaction type (targeted versus incidental), which in turn were directly related to fishing region (Table 3). Some of the differences in fishing techniques may be due to attitudes about nuisance versus desirable species, which is compounded by regional variation in fishing and species-specific traits of the sharks. There were differences in angler behaviour and attitudes based on the type of shark caught (target versus bycatch), which was directly related to fishing region and whether the angler targeted sharks (Table 3). Dogfish, for example, are commonly caught as bycatch in Atlantic recreational fisheries, almost entirely in the north-east region. Dogfish were often caught by anglers who are not targeting sharks (60%). Many of the respondents that had caught dogfish made negative comments about their prevalence in the environment and the frequency of catching them instead of their intended catch. For example, one wrote: 'I do feel dogfish populations have a negative impact on cod and haddock [*Gadus morhua* and *Melanogrammus aeglefinus*] stocks. In the summer dogfish can swarm the fishing grounds and can be impossible to avoid'. Another wrote, 'I really don't care about dogfish health'. Respondents that targeted desirable species (i.e. those that presented a challenge to catch), like blacktip sharks, *Carcharhinus limbatus*, were more likely to follow best handling and release practices, including using circle hooks, leaving the shark in the water, and taking measures to revive the shark. This example supports several recommendations: (1) the differences in how target and incidentally caught species were treated suggests that best practices for shark fishing may need to be marketed to anglers who do not intend to catch sharks; and (2) with nearly 70% of the respondents having interest in information on how to reduce shark bycatch, such as specialized gear and avoidance techniques, additional research into the effectiveness of practices to reduce post-release mortality would be beneficial to the community. Nguyen *et al.* (2012) surveyed sockeye salmon anglers in the lower Fraser River British Columbia and revealed that despite it being a superficially homogenous group (in terms of demographics, target and site), the respondents had different preferences for how they received information on best practices. Given the apparent diversity and heterogeneity among respondents in the shark survey, it is reasonable to assume that components of best capture and handling practices and a dissemination strategy may need to be at least region specific.

The demonstrated desire to promote shark survival along with the lack of adherence to NMFS recommendations suggests that the adoption of best catch-and-release practices holds promise, but must be better disseminated. It is possible that many anglers, even those with many years of experience, may not be familiar with recommended best practices for catching and releasing sharks. One respondent with 40 years of fishing experience worried about the knowledge that other anglers had regarding handling sharks 'Not many people out here know how to care for shark, and fewer know how to safely land one. I do not, and so do NOT fish for sharks'. Best fishing practices may not reach anglers because they may not look for fishing information or do not trust information from the sources that distribute them. Each year, there are new entrants into saltwater angling; in a private survey, the Recreational Boating and Fishing Foundation (2012) found that 9.8% of recreational anglers were trying the sport for the first time in 2013. Among first-time fishing licence buyers, 'friends and family who are experienced angers' was the primary way information about fishing is obtained

(57%) with state fish and wildlife agency websites a distant second (29%) (RBFF, 2012). Among anglers who fished in the last year, state agencies were consulted less frequently (<40%) than magazines, websites, and television (50–80%) (ASA, 2015). Additionally, trust in fisheries information may vary by scale, with anglers more likely to trust information from state and regional rather than federal governments (Gray *et al*., 2012).

A purposive snow-ball internet survey was used, which although having some limitations (Fricker and Schonlau, 2002; Beidernikl and Kerschbaumer, 2007), enabled participation from a group that would otherwise be difficult to reach. Because of this approach, caution must be adopted in the extrapolation of findings to the general population. Although the study intended to include a broad distribution of responses across regions, angler demographics, and angler experience level, the results may have been affected by a sampling bias. Online snow-ball surveys that exploit social media and other communication channels have major strengths, including convenience, low cost, the ability to draw a large sample, and reduced interviewer effects, but there are weaknesses as well, such as a skewed sample (Duffy and Smith, 2005; Evans and Mathur, 2005). Based on a 2013 Angler Catch Survey carried out by NMFS of anglers who went fishing in the past year (NMFS, 2013), the survey results presented here were skewed towards college level educated or higher men. The reported number of years fished, years fished per day, and importance of fishing as part of their lifestyle, suggest that the respondents are more experienced than the average angler compared with those in the Catch Survey (28.4% fished 5 days or less, 17% fished between 11 and 20 days, and 41.7% did not fish at all in the past year) (NMFS, 2014b). Individuals exposed to the survey are more likely to be avid anglers because those activities and organizations require either time or money to access. The regional skew that was found in this survey may be due to recreational saltwater fishing activity (number of individuals and trips per year) being greater on east coast (55%) and Gulf coast (35%) than the west coast (8%) (NMFS, 2014b). In addition, more fishing forums and thread topics targeted anglers in eastern regions of the USA and the users of these are very active on the discussion boards. Despite searching out forums that targeted western and island states, very few respondents fished in those areas. In addition, the title of the survey and all of the media promoting it said that it was about encountering sharks while fishing. This may have attracted more anglers that participate in shark fishing than would otherwise have responded. Thus, the results from this sample only represent the behaviours and attitudes of anglers that are avid fishers and are likely to target sharks. To obtain a more balanced sample, in-person shore and dock intercept surveys could be conducted in the future.

Although relevant for anglers globally, this survey only targeted participants in the United States. Arlinghaus *et al*. (2007) points out that the human dimensions of catch-and-release fishing in each country are complex because people fish for a wide variety of reasons (Felder and Ditton, 1994; Arlinghaus and Mehner, 2004) and have different cultural backgrounds (Lyman, 2002; Wolfe, 2006), not to mention different taxonomic groups. This study took a focused approach to anglers in the USA and found that behaviours and attitudes varied between regions, suggesting that even within country there are subcultures of shark fishing. In the future, surveys can be used to compare broader geographic regions as well as different demographics.

Given the increasing global participation rates in recreational angling, best capture and handling practice guides for elasmobranchs are essential to enhancing their survivorship. Before developing specific guidelines, it is important to evaluate how recreational anglers presently perceive the capture of sharks and what capture and handling practices are currently used. As demonstrated by this survey, many anglers exhibit positive attitudes toward sharks, which were related to a desire to increase shark survival through fishing techniques. However, there were a number of situational factors that contributed to the decisions that recreational anglers made about fishing methods. Cooke and Suski (2005) argue that for these reasons, species- and situation-specific catch-and-release practice guidelines that take into account diversity of fishes and variation in situational fishing techniques are necessary for better fisheries management. As suggested by Cooke *et al*.

(2013), one way to achieve voluntary adoption of best practice catch-and-release guidelines may be through a partnership between fisheries managers and avid anglers, such as those sampled here. In addition, directly involving avid anglers in the research and development of situation- and species-specific best practices may increase angler confidence that changes they make to their fishing behavior would benefit shark survival (Danylchuk *et al.*, 2011). This study suggests that avid anglers' understanding of the importance of sharks, threats to sharks, and how to catch-and-release sharks to increase their survival can be leveraged to support best practices throughout the wider fishing community and to promote shark conservation.

ACKNOWLEDGEMENTS

Support was provided by the National Science Foundation Integrative Graduate Education and Research Traineeship Program (IGERT) at University of Massachusetts Amherst and New England Aquarium. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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