

Conservation Implications of Land-Based Trophy Shark Fishing

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Abstract

Recreational fishing is increasing globally as is the percentage of sharks that comprise global catches. Sharks are among the most threatened vertebrate species due to their K-selected lifestyle, and there is a need to understand better recreational fishing and its potential contribution to shark population declines. Recreational fisheries can have significant impacts on fish populations, but the sector has received far less attention, research and management compared to commercial fisheries. A subset of recreational fishing, land-based shark fishing, has seen an apparent recent boost in popularity but limited information exists as to the extent of the activity and the motivations and practices of its anglers. In our initial assessment of land-based recreational fishing around Australia and its threat to shark populations, we found that recreational fishing of sharks from land-based locations around Australia is likely to be higher than previously reported and that a high proportion of the sharks targeted are classified as Threatened and Near Threatened according to the International Union for Conservation of Nature. Most of the recreational anglers generally had positive attitudes towards sharks and shark conservation, however their behaviours and practices did not reflect these positive beliefs as evidenced by unnecessary handling and other rough practices. This inconsistency may be driven by limited information, inaccurate perceptions of online community consensus and the negative portrayal of sharks by the media. Management can seek to improve adherence to guidelines through dissemination of information focussing on peer-to-peer communication whilst liaising with the media and using social media as a tool in the promotion of pro-environmental behaviours.

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INTRODUCTION

Globally, many populations of shark species are undergoing rapid and widespread decline. Currently, 30% of shark species are classified as threatened with extinction by the International Union for the Conservation of Nature (IUCN) (Dulvy et al., 2014) and some populations have already gone locally or regionally extinct (Baum, 2003; Baum and Myers, 2004; Roff et al., 2018). Sharks play important roles in the structure and functioning of marine communities and are essential to the health and stability of marine ecosystems (Barbini et al., 2015; Barley et al., 2017; Ferretti et al., 2010; Heithaus et al., 2007; Lynch et al., 2010; Myers et al., 2007; Ruppert et al., 2016). Most shark population declines are attributed to the direct and indirect effects of fishing (Stevens et al. 2000). Sharks are naturally vulnerable to exploitation due to their conservative K-selected life history strategies of slow growth, late maturity and low fecundity (Stevens et al. 2000, Lynch et al. 2010, Dulvy et al. 2014). Whilst commercial fishing is widely recognised as the greatest threat facing sharks, recreational fishing can also have a significant impact (Gallagher et al., 2017; Kyne and Feutry, 2017) given the rapid rise of this activity more generally (Freire et al., 2020).

According to the most recent Australia-wide survey, approximately 3.4 million Australians engage in recreational fishing each year (Campbell and Murphy, 2005) catching an estimated 1.2 million sharks (McLoughlin and Eliason, 2008). Recent fisheries reconstructions by *Sea Around Us* have also estimated that recreational fishing accounted for approximately 14% of Australia's total catch in 2014, and of this, approximately 12% of Australia's recreational catch was sharks (Kleisner et al., 2015). Land-based shark fishing is a type of recreational activity that involves fishers targeting sharks from shore, generally by chumming inshore areas or paddling out bait on kayaks and then returning to shore. Once the shark is on the hook there is usually a long, extended fight and often the shark is dragged out of the water onto land (Shiffman et al., 2017). The activity has recently seen an apparent boost in popularity which is partly attributed to social media, as anglers can post photos online and communicate their accomplishment to a wide audience (Darimont et al., 2017; Shiffman et al., 2014). Land-based activities also require little financial input making them accessible to a larger proportion of the population.

Although these land-based shark anglers usually practice catch and release, some species are still susceptible to strong physiological stress responses due to the trauma and length of capture.

This stress can have negative consequences on their normal biological processes affecting the individual's survival or subsequent role in the population (Arlinghaus et al., 2007; Brooks et al., 2012; Gallagher et al., 2014; Skomal and Mandelman, 2012). Certain species such as hammerhead sharks *Sphyrna* spp. have been shown to have a greater vulnerability to the stress and mortality resulting from capture (Gallagher et al., 2014). These adverse physiological effects are further compounded by unnecessary rough handling, as the sharks are dragged by the hook from the water's buoyant support, across abrasives surfaces onto land where they are subjected to additional stress and injury, further decreasing release survivorship (Gallagher et al., 2017; McLoughlin and Eliason, 2008). As this type of fishing selectively targets the largest individuals, this can also have a large, disproportionately negative impact on shark populations even with the removal or harm of only a few individuals (Gallagher et al., 2017; Shiffman et al., 2014; Stevens et al., 2000).

In Australia, most sharks can be legally caught by recreational anglers, except those few under national protection of the Environmental Protection and Conservation Act 1999 (EPBC) (Department of Agriculture, Water and the Environment). Individual state and territory authorities are responsible for implementing controls to regulate catches. However, the majority of these regulations do not cover the full scope of recreational shark fishing. The practice of catch-and-release acts as a loophole in existing regulations through which these anglers can target any species and as many individuals as possible; the angler is still legally compliant so long as the shark is released, regardless of condition. Given the magnitude of recreational angling in Australia, the apparent increase in land-based shark angling and the potential for serious post-release effects, this type of fishing could have a significant impact on sharks and may represent a large and growing risk to already vulnerable populations (Cooke and Cowx, 2004; Dulvy et al., 2014). Assessing the scale of this activity, understanding recreational angler behaviour, motivations and practices, and identifying the potential impacts on shark populations is crucial to the long-term conservation of shark species around Australia.

Recreational anglers come from a range of socio-economic backgrounds, pursue different fishing experiences, and exhibit differing levels of commitment to fishing (Nguyen et al., 2013; Shiffman et al., 2017). The motivations for recreational fishing are often complex, multidimensional and relate to both catch and non-catch aspects of the activity (Fedler & Ditton 1994). It is therefore necessary and advantageous for management to gain a complete understanding of specific angler motivations, as sub-populations of recreational anglers can

differ substantially. The implementation of strategies that allow management to successfully promote conservation whilst avoiding the alienation of anglers whose cooperation is vital, also requires detailed understanding of the knowledge, attitudes, perceptions and practices of the specific subpopulation of anglers (Cooke et al., 2013; Gallagher et al., 2014). Understanding anglers' motivations and behaviours can provide direction and support in the development of effective strategies that greatly increases the likelihood of adherence to new regulations. Awareness of anglers' beliefs and values, and overall understanding of issues can also assist in the communication of strategies, as messages can be better tailored whilst still maintaining the integrity of the science (Shiffman, 2020). In Australia, studies of recreational shark fishing have primarily focused on boat-based anglers (French, 2017; Lynch et al., 2010; McClellan et al., 2016), while land-based anglers are comparatively understudied.

Assessing the impact of recreational fishing and directing future conservation and management initiatives also requires adequate information, which most marine recreational fisheries lack due to geographically dispersed activities and limited resources (Gallagher et al., 2017; Monkman et al., 2018a). There is increasing recognition that social media can provide a cost-effective, discreet and useful method of obtaining baseline data (Monkman et al., 2018b) for conservation science (Toivonen et al., 2019), fisheries research (Giovos et al., 2018; Martin et al., 2014; Shiffman et al., 2017), and is increasingly being used as a tool to assess the magnitude of illegal hunting around the world (Braden, 2014; Eid and Handal, 2018; Essen, 2016). An online fishing forum was used to investigate land-based shark fishing in Florida, USA, which successfully documented the nature and scale of the activity, resulting in policy changes and instigation of new fishing handling regulations to enhance protection of threatened shark species (Shiffman et al., 2017).

To investigate land-based recreational fishing in Australia, images were collected from social media and an online survey was designed and promoted with the goal of gaining initial information on this previously 'cryptic' activity and its potential conservation implications. The data collected assess: (1) the scale of the fishery, the species targeted and the threat to at-risk to species (2) recreational fishers' handling practices and release methods whilst shark fishing and (3) recreational fishers' attitudes, motivations and perceptions in regard to sharks and shark fishing.

METHODS

Survey

Online methods of recruitment offer scientists a new way of accessing a greater number of individuals in a short period of time. Social media are increasingly used as a means to recruit potential participants with unprecedented precision through targeted advertisements that can be promoted to specific target audiences via demographics such as location, age and gender. Facebook is the most popular social media platform worldwide, with an estimated 2.5 billion monthly active users (Statista, 2014). As a result of Facebook's widespread use, relative anonymity and ability to target users, numerous studies have used paid Facebook ads as a recruitment tool, predominately in health research (Arcia, 2014; Kayrouz et al., 2016; Whitaker et al., 2017; Wozney et al., 2019). The use of social media provides a faster, more efficient and cost effective way to recruit a large number of study participants compared to traditional methods such as telephone interviews, mail-outs, newspaper advertisements and flyers (Thornton et al., 2016; Whitaker et al., 2017). The ability of online research to provide access to difficult to reach or 'hidden' populations, such as people engaging in illegal activities or behaving atypically, has also drawn the attention of researchers (Miller and Sønderlund, 2010; Temple and Brown, 2011).

To harness the potential of Facebook to recruit survey participants, a questionnaire was promoted through Facebook to users that exhibited interests in recreational fishing. This questionnaire collected data on angler knowledge, opinions and actions with respect to shore-based trophy shark fishing in Australia. The target population was recreational anglers aged 18 and over, fishing in waters around Australia. Data collection took place over 12 weeks beginning in January 2020. A pilot survey was first tested with a small group of participants, whose comments were incorporated into a revised version before its promotion. The survey was hosted by Qualtrics (Qualtrics, 2020) and was active from January to March 2020 (Supplementary Information 1). The questionnaire was anonymous and voluntary. Qualtrics restricted access to the survey such that only one response was permitted per IP address to prevent any potential bias caused by a few individuals repeatedly taking the survey. To encourage participation a lottery was concurrently run in which questionnaire respondents had the opportunity to go into the draw to win one of ten vouchers to a national outdoor recreation chain-store. The survey was undertaken under UWA Human Ethics Approval (RA/4/20/5621) and complied with guidelines, including providing potential participants with all of the necessary information via the "Participant Information Form" (Supplementary Information 2).

Participants were required to read and understand the document prior to giving their consent electronically by clicking “agree” to the following statements: (1) I have read and understood the information provided in the Participant Information Form, (2) I voluntarily agree to participate and (3) I am 18 years or older.

Procedures

At the start of the recruitment period, a Facebook page was created that was dedicated to our research (Supplementary Information 3). A survey flyer was created and added to the Facebook page, and a series of four paid promotional ad campaigns was run over the 12 weeks (Supplementary Information 3). The two ads comprised a succinct description about the research, promotion of the lottery and a hyperlink that directed the potential participant to the survey homepage and consent form hosted on the Qualtrics platform. The first two ads had images of fishing rods on a beach with a silhouette of a shark superimposed with the words “Do you fish for sharks” “Have you ever caught a shark” and the final two ads were simpler without superimposition or words (Supplementary Information 3). The images were chosen intentionally to invoke recall of firsthand experiences of fishers catching sharks from shore. Within the Facebook ad manager, audience-targeting fields were selected to promote ads to users with specific interests and demographics (e.g. Australia, 18-65+, angling, recreational fishing, big-game fishing etc.).

Design

The questionnaire was adapted from McClellan et al. (2016) and comprised six sections: (1) general fishing questions, (2) encounters and interactions with sharks, (3) shark fishing techniques, (4) knowledge about sharks, (5) opinions on sharks, and (6) shark fishing and demographic information (Supplementary Information 1). Branching logic was used to separate respondents who directly targeted sharks from those who only caught sharks accidentally or had never caught a shark (Figure 1). In Section 1, all respondents were asked questions about their fishing experience (number of years they had been fishing), how often they go fishing and asked them to rank the importance of fishing as part of their lifestyle. In Section 2, respondents were asked if they directly target sharks. If the answer was ‘yes’, they answered questions about how often, why, where and when they targeted sharks and which species, the details of which (species, size, location, gear, landing time) were requested in Section 3. Depending on whether

the shark was kept or released, the respondent was asked to select the options that best described the reasons behind the decision. If they answered no, then they were asked if they accidentally caught sharks while fishing. If they answered no, indicating they had never caught a shark, they were advanced to Section 4 where respondents were asked general knowledge questions about sharks. Section 5 asked respondents about their beliefs and opinions on sharks and shark fishing to develop an attitudinal scale using questions adapted from Lynch et al. (2010). They were asked to rate their agreement with statements using a Likert scale: (1) strongly agree, (2) somewhat agree, (3) neither agree nor disagree, (4) somewhat disagree, and (5) strongly disagree. Section 6 asked respondent's basic demographic questions, including: age, gender, state, postcode, education and employment.

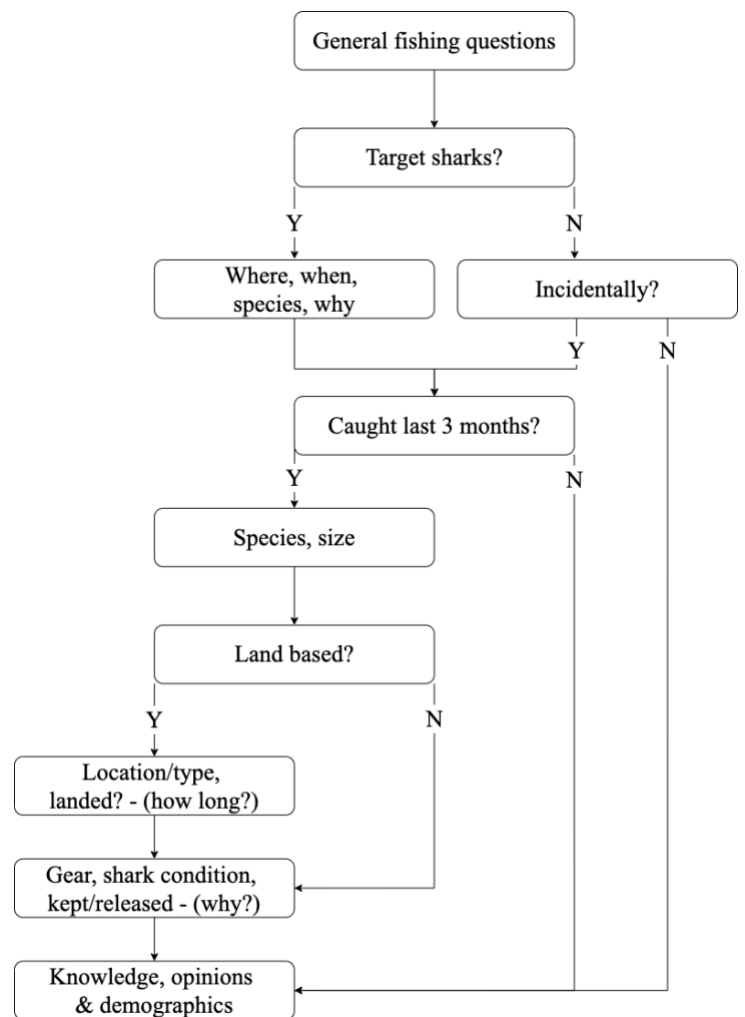


Figure 1: A representative diagram of the questionnaire survey created to collect responses from recreational anglers using branching logic. Depending on whether they targeted sharks, incidentally, caught sharks (by-catch) or never caught sharks they were asked a series of questions to determine knowledge, attitudes, perceptions and practices towards sharks and shark fishing.

Statistical Analysis

Respondents were asked to identify the species of shark they either targeted or incidentally caught most often, and to recall the species they caught in the last three months. Choosing from a list of possible options or describing their own, any answers that could not be identified or that described a ray species (commonly shovelnose ray, *Aptychotrema* sp. and fiddler ray, *Trygonorrhina* sp.) were deleted in the analysis.

Summary statistics were calculated for all questions in Sections 1-4 and 6. The questions in Section 5 were grouped to measure overall beliefs and opinions for four different attitudinal domains: (1) value of catching a shark; (2) importance of releasing sharks in good condition;

(3) value of sharks to ecosystems; (4) threats to sharks; and (5) importance of management to sharks. The answers to the statements in each domain were averaged to create a separate Likert scale for each domain. Negative statements were reverse coded prior to analysis in RStudio (RStudio Team 2018). Using the *psych* package (William, 2019) a Cronbach's alpha reliability coefficient was calculated for each domain and an alternate alpha-if-item-deleted statistic calculated for each item. To improve reliability, attitudinal domains 4 & 5 (question 37 and 38 in Supplementary Information 1) were combined for analysis. As the Likert scale domains are ordinal, non-parametric tests were used to analyse the relationships between the four domains as well as Pearson's chi-square test of independence.

Social media

Online research, and specifically data mining from social media, is useful for studying a large volume of information obtained across a wide-spread and diverse population. This is a form of unobtrusive, nonreactive research in which the subjects under investigation are unaware they are being studied so their behaviour is unaffected by the data collection (Fielding et al., 2017). This approach is useful for controversial topics as subjects may alter their behaviour or become hostile toward researchers if they become aware, they are being studied. Investigations based on photos and videos uploaded to social media have been previously used as an alternative approach to access information and assess recreational fishing in terms of species, techniques, location and fishing effort (Belhabib et al., 2016; Giglio et al., 2020; Giovos et al., 2018). In this study, Facebook and Instagram (a popular photo-sharing app with 1-billion active monthly users (Statista, 2018)) were used to gather images on shark species targeted by land-based recreational fishers around Australia. Human ethics approval was obtained from the University of Western Australia prior to commencing (RA/4/20/5621). Investigations were carried out on public and freely accessible groups and pages on Facebook and Instagram. No personal pages of fishers were visited, no personal information was collected, and there were no interactions with the people posting content.

Procedure

Public groups, pages and accounts were identified by keywords or searching hashtags using combinations of the following terms: "shark fishing", "Australia", "land-based". The search was restricted to images posted by recreational fishers in Australia fishing from land-based locations (e.g. beach, river, jetty, bridge, pier or groin etc.). Images were downloaded and stored on an encrypted drive. The images were reviewed to identify any duplicates, and these were

removed, as well as any others in which there was uncertainty about the location or type of fishing (land-based/boat-based) used to catch the shark, and/or species identification. The remaining photos were examined in detail to determine the species caught, the land-based fishing location (e.g. beach, jetty, bridge) and handling behaviour (e.g. the sharks' tail or head was lifted). Sharks were recorded as "landed" or "not landed" following the same methodology used by Shiffman et al. (2017) in which sharks were verified as "landed" if the image unequivocally showed that the shark was completely out of the water and "not landed" if any part of the shark was still in any depth of water. It is important to acknowledge that this method only collects information on shark catches that anglers voluntarily post online and thus represents a minimum count. This method may also result in biases towards particular species of sharks and the reporting of sharks as landed, as anglers preferentially post photos of landed sharks as opposed to sharks still in the water. All species were classified according to their international IUCN status, and national Australian Red List status and Australian Fish Stock status (Simpfendorfer et al. 2019, IUCN 2020). At-vessel mortality rates for each species were also included after a review of the literature.

RESULTS

Survey

Respondent demographics

There were 319 recreational anglers that completed the survey over the three-month period. Ninety-two percent of the respondents were male and 60% were less than 40 years old. Only 25% of respondents reported holding a university degree or higher, while 40% had completed a trade or an apprenticeship. The majority (83%) of the respondents ranked fishing as an important part of their lifestyle. Half of respondents stated having more than 20 years fishing experience (55%) and reported going fishing at least once a week (47%). Most respondents lived in WA (27%), with slightly fewer living in QLD (18%), NSW (15%), VIC (15%) and SA (13%), with very few living in NT (6%), TAS (4%) and ACT (2%).

Catch information

The majority of respondents reported actively targeting sharks (66%), while the remainder (34%) only caught sharks incidentally as bycatch. Forty-nine percent of those that did target sharks, did so more than ten days per year. The three main reasons respondents targeted sharks were "to eat for food" (38%), "excitement/thrill of the catch" (36%) and "opportunity to interact with large marine predators" (21%). Respondents who targeted sharks reported going fishing

between 6 pm and 11 pm (50%) and most frequently in the summer months (December (50%), January (53%) and February (50%)).

Respondents who stated that they targeted sharks most often caught bronze whaler *Carcharhinus brachyurus* (28%), bull shark *Carcharhinus leucas* (22%), gummy shark *Mustelus antarcticus* (16%), tiger shark *Galeocerdo cuvier* (10%) and shortfin mako *Isurus oxyrinchus* (8%). The respondents who reported catching sharks accidentally, most often caught bronze whaler (33%), bull shark (22%) and sicklefin lemon *Neopaprio acutidens* (7%). The respondents that reported catching a shark within the last three months, caught sharks more often from land (59%, n=132) than boats (41%, n=93). Of the respondents that recalled catching a shark from a land-based location within the last 3 months, most frequently caught bull shark (30%), bronze whaler (27%), gummy shark (10%) and tiger shark (5%) (Table 1). According to the IUCN Red List 16% of the species caught were classified as threatened (i.e. had a status of either Vulnerable (n=10), Endangered (n=4) or Critically Endangered (n=5)) and 66% as Near Threatened (n=81) (Table 1).

Table 1: Counts of sharks targeted or incidentally caught from land-based locations within the last three months by respondents with scientific names and corresponding IUCN status: DD (Data Deficient), LC (Least Concern), NT (Near Threatened), VU (Vulnerable), EN (Endangered), & CR (Critically Endangered).

Common Name	Scientific name	Count	IUCN
Bull shark	<i>Carcharhinus leucas</i>	36	NT
Bronze whaler shark	<i>Carcharhinus brachyurus</i>	33	NT
Gummy shark	<i>Mustelus antarcticus</i>	13	LC
Tiger shark	<i>Galeocerdo cuvier</i>	6	NT
Hammerhead shark, unspecified ^a	<i>Sphyrna</i> spp.	5	CR
Port Jackson shark	<i>Heterodontus portusjacksoni</i>	4	LC
Whaler shark, unspecified ^b	<i>Carcharhinus</i> spp.	3	NT
Blacktip reef shark	<i>Carcharhinus melanopterus</i>	3	NT
Draughtsboard shark	<i>Cephaloscyllium laticeps</i>	3	LC
Dusky shark	<i>Carcharhinus obscurus</i>	3	EN
School shark	<i>Galeorhinus galeus</i>	3	VU
Sicklefin lemon shark	<i>Negaprion acutidens</i>	3	VU
White shark	<i>Carcharodon carcharias</i>	2	VU
Wobbegong shark	<i>Orectolobus</i> spp.	2	LC
Grey nurse shark	<i>Carcharias Taurus</i>	1	VU
Thresher shark	<i>Alopias vulpinus</i>	1	VU
Zebra shark	<i>Stegostoma fasciatum</i>	1	EN

^a Great (*S. mokarran*) 4, unspecified 1

^b Spot-tail (*C. sorrah*) 1, spinner (*C. brevipinna*) 1, unspecified 1

* Nationally protected species

Fishing methods

The majority of respondents that reported catching a shark in the last three months while land-based fishing recalled their location as from a beach (65%). Ninety percent of the sharks were brought to shore, with the largest proportion reporting a fight time greater than 2 hours (30%), followed by landing times ranging between 1 – 5 minutes (18%), 6 – 10 minutes (17%), and 11 – 20 minutes (15%). More than half of the released sharks were taken out of the water (62%) and all reportedly for less than a minute (100%).

Respondents that caught a shark in the last three months from a land-based location reported releasing 80% of the captured sharks. Of the sharks that were targeted and incidentally caught, 77% and 88% were released, respectively. One hundred and thirty-two respondents offered one or more reasons for releasing the last shark they caught while land-based fishing, with the most common reason being that they always practice catch-and-release when fishing for sharks (54%). Many respondents considered the shark to have important ecological value (40%) and some said that they were not trying to catch the shark (18%). Other explanations for releasing sharks included the notion that the sharks lack ‘value’ (13%) or that the meat/flesh is inedible (12%). Fewer respondents cited the need to comply with policy or legal regulations such as legal-size limit (6%), bag/possession limit (2%) and species identification (1%). Of those respondents that did retain the shark, the majority considered the sharks edible (92%). One respondent believed that the shark would not survive release and one retained the animal to show friends and family. Nearly all sharks caught by respondents were hooked in the mouth or surrounding area (86%). Two sharks were hooked in the throat, one in the stomach and one in the gills, and 96% of respondents generally removed hooks. Natural rather than artificial bait was typically used (97%). Of the respondents that described their hooks, 35% reported using circle hooks and the size of hooks varied, ranging from 1/0 to 24/0.

Attitudinal responses

Respondents had strong positive beliefs with attitudinal questions regarding the overall importance of releasing sharks in a good condition (86%), including acknowledging that the landing of the shark has an overall impact on the sharks post-release survival (75%) and indicated that they would be willing to use tackle and handling practices that minimise damage to the sharks (84%). Respondents were in agreement with statements that described the value of sharks to ecosystems (82%). Respondents also recognised the importance of having viable

populations of sharks (93%), agreed that sharks are a sign of a healthy marine ecosystem (92%), and enjoyed seeing sharks in the ocean (86%).

There was less agreement with statements regarding threats and the importance of management to protect sharks as the overall domain results were somewhat tied (Table 2). Nearly half of respondents agreed that recreational fishing affects the health of shark populations (48%) but were divided over whether more regulations on recreational fishing are needed and agreed that current management measures and restrictions are enough to conserve sharks (60%). There was general consensus that commercial fishing is a threat to shark populations (79%).

Half of the respondents agreed with statements that place a high value on catching a shark (52%). Most enjoyed the challenge of catching a shark (75%), explaining that catching a shark added to the enjoyment of their fishing trip (65%). Respondents agreed that sharks are good to eat (60%) although 64% reported that they would prefer to catch other fish.

In terms of the willingness to adopt management options with regard to shark conservation, the majority of respondents were most willing to adopt size limits as their first option (40%), seasonal restrictions second (29%), area restrictions third (30%), gear restrictions fourth (45%) and banning practices was the option they would be least willing to adopt (65%) (Figure 2).

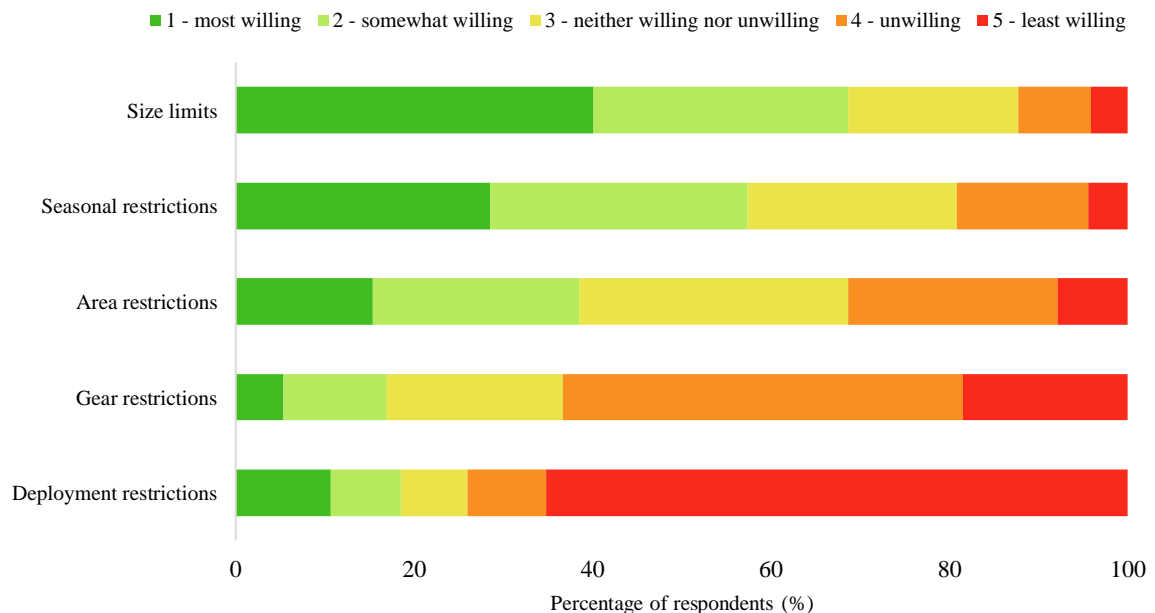


Figure 2: Recreational anglers' rank of five management options with regard to shark conservation based on their willingness to adopt the measures (1: most willing to 5: least willing) shown by percentage of respondents.

Table 2: Attitudinal domains comprised of sets of questions that reflect recreational anglers' responses beliefs about catching, releasing, threats and management of sharks. Measured on a five-point Likert scale ranging from 1 = strongly agree to 5 = strongly disagree. α represents Cronbach's alpha reliability coefficient ($\alpha > 0.7$ = good reliability). The attitudinal questions were adapted from Lynch et al. (2010).

Attitude domains and statements	Disagree (%)	Neutral (%)	Agree (%)	Mean score	α if item deleted
Value of catching a shark ($\alpha = 0.84$)	27	21	52	2.6	
Catching a shark adds to the enjoyment of my fishing trip	18	17	65	2.3	0.80
I prefer to catch fish rather than sharks _a	9	28	64	4.0	0.82
Sharks are good to eat	19	21	60	2.4	0.85
I enjoy the challenge of catching a shark	14	11	75	2.0	0.80
Catching a shark wastes my fishing time _a	60	21	19	2.3	0.81
I target sharks when I go fishing	36	19	45	3.0	0.80
Sharks are a threat to other fish I want to catch _a	53	27	20	2.4	0.87
Importance of releasing a shark in good condition ($\alpha = 0.8$)	4	10	86	1.5	
I like to make sure that a shark is released in good condition	1	8	91	1.3	0.73
It is important that all the sharks I release survive	2	7	91	1.3	0.71
The landing of the shark has an impact on the survival of the shark after release	8	17	75	1.9	0.84
I would be willing to use tackle and special handling practices that minimizes damage to released sharks and improves its chances of survival	5	11	84	1.6	0.75
It does not matter to me whether a shark survives after I release it back into the ocean _a	88	6	7	1.5	0.76
Value of sharks to ecosystems ($\alpha = 0.81$)	7	11	82	1.7	
It is important to have viable populations of sharks	1	5	93	1.3	0.77
Sharks are a sign of a healthy marine ecosystem	1	7	92	1.4	0.77
Sharks are of little use or importance to humans _a	69	19	12	2.0	0.81
It would be better and safer if there were fewer sharks in the ocean _a	68	19	14	2.0	0.79
I enjoy seeing sharks in the ocean	4	10	86	1.6	0.78
Sharks are an irrelevant part of the ecosystem _a	87	6	8	1.6	0.80
Sharks should be conserved as they have a right to exist	6	13	81	1.7	0.80

Threats & importance of management ($\alpha = 0.65$)	33	28	38	2.9	
Recreational fishing does not affect the health of shark populations ^a	28	25	48	3.4	0.60
Commercial fishing is a threat to shark populations	11	9	79	1.9	0.65
Sharks need to be protected	18	26	56	2.5	0.54
Climate change poses the greatest threat to sharks	38	37	25	3.3	0.61
Current management measures and restrictions conserve sharks ^a	7	34	60	3.7	0.67
More regulations are required for recreational fishing of sharks	37	28	35	3.1	0.54
Current management restrictions are too strict and/or interfere with my fishing ^a	38	41	21	2.8	0.63

^a Items reverse coded for calculation of overall score

^b For ease of presentation positive (strongly agree, somewhat agree) and negative (strongly disagree, somewhat disagree) categories have been grouped.

Attitudinal responses and fishing experiences and knowledge

The importance of releasing a shark in a good condition differed by respondents' knowledge as to whether sharks produce more offspring than other fish ($P < 0.05$) as respondents with correct knowledge of shark offspring were more likely to agree with the important of release condition. The value of sharks to ecosystems differed according to the respondents' knowledge of the number of shark species ($P < 0.05$) as respondents with correct knowledge of shark species were more likely to agree with the value of sharks to ecosystems. Respondents' knowledge of threats and importance of management differed according to how often respondents fished for sharks ($P < 0.001$) with those fishing more frequently being more likely to answer neutrally to statements regarding threats and management of sharks.

Respondents who agreed with statements regarding the value of catching sharks were more likely to also agree with statements regarding the importance of releasing a shark in a good condition and the value of sharks to the ecosystem, and more likely to be impartial to statements about the threats and management of sharks (Table 3).

Table 3: Results of Chi-square tests of independence (p-values) performed between the four attitudinal domains.

	Importance of releasing a shark in a good condition	Value of sharks to ecosystems	Threats and importance of management to sharks
Value of catching a shark	<.0001	<.0001	<.0001
Importance of releasing a shark in a good condition		<.0001	<.0001
Value of sharks to ecosystems			<.0001

Social media

A total of 674 individual sharks representing 24 species from 9 families were observed in images downloaded from social media. Carcharhinidae ($n = 12$ species) was the most represented family. The most caught species was tiger shark with 166 individuals (25% of the total), followed by bull shark (21%) and bronze whaler (14%). Most of sharks in the images were "landed" (60%) and the remaining were "not landed" (40%) (see examples in Figure 3). The majority of sharks were caught from beaches (89.5%), some were caught from man-made structures (e.g. jetty, bridge, pier) (7%) and the remaining caught from river shorelines (3.5%). Images also revealed rough handling of the sharks as almost half had their tails lifted above the

natural curvature of their spines (48%, n = 315) and some had their heads pulled back to force open their jaws to reveal teeth (8%, n = 55).

Regarding the conservation status of captured species, nine species are globally classified as Vulnerable (36%), six are Near Threatened (24%), four are Endangered (16%), three are Critically Endangered (12%) and three species are Data Deficient (12%). Near Threatened species represent the highest abundance (n = 338 individuals, 50%), followed by Data Deficient species (n = 123, 18%), Vulnerable (n = 118, 18%), Critically Endangered (n = 61, 9%) and Endangered (n = 34, 5%; see Table 3). According to Australia's Red List, 68% of the individuals caught were assessed with a status higher than that of Least Concern (Simpfendorfer et al. 2019). With respect to the Status of Australia's Fish Stocks, fourteen species caught were assessed as being sustainable (56%), six as depleted (24%), three as recovering (12%) and two as depleting (8%) (Simpfendorfer et al. 2019). For the species regularly observed in images (n>10), estimates of at-vessel mortality in commercial longline fisheries have a median value between the upper and lower limits of 35% and 74%, respectively (Table 3).

Table 4: Counts of sharks documented in social media images by land-based recreational fishers with corresponding Australian Red List (ARL) and International Union for Conservation of Nature (IUCN) status: DD (Data Deficient), LC (Least Concern), NT (Near Threatened), VU (Vulnerable), EN (Endangered), & CR (Critically Endangered), last IUCN assessment year and status of Australian Fish Stocks (SAFS) (Simpfendorfer et al., 2019). At-vessel mortality (AVM) range in percentage for each species as reported in the literature from sources: (1. Beerkircher et al., 2002; 2. Braccini et al., 2012; 3. Braccini and Waltrick, 2019; 4. Butcher et al., 2015; 5. Campana et al., 2016; 6. Coelho et al., 2012; 7. Epperly et al., 2012; 8. Fernandez-Carvalho et al., 2015; 9. Gallagher et al., 2014; 10. Gulak et al., 2015; 11. Morgan and Burgess, 2007; 12. Morgan and Carlson, 2010; 13. Reid and Krogh, 1992; 14. Stobutzki et al., 2002)

Common Name	Scientific Name	Count	ARL	SAFS	IUCN	IUCN assessed	AVM %	AVM source
Tiger shark	<i>Galeocerdo cuvier</i>	166	NT	Depleting	NT	2018	2.9 – 8.5%	4, 6, 10, 11
Bull shark	<i>Carcharhinus leucas</i>	139	NT	Sustainable	NT	2005	2.5 – 15%	10, 12
Bronze whaler shark	<i>Carcharhinus brachyurus</i>	97	LC	Sustainable	NT	2003	36.2%	2
Sicklefin lemon shark	<i>Negaprion acutidens</i>	58	LC	Sustainable	EN	2003	0%	3
Great hammerhead shark	<i>Sphyrna mokarran</i>	41	VU	Depleted	CR	2018	56 – 93.8%	10, 11
Dusky whaler shark	<i>Carcharhinus obscurus</i>	28	NT	Recoveringw/Undefined ^e	EN	2018	27.9 – 81%	4, 9, 10, 11
Tawny shark	<i>Nebrius ferrugineus</i>	20	LC	Sustainable	VU	2003	n/a	
Sevengill shark	<i>Notorynchus cepedianus</i>	17	LC	Sustainable	DD	2005	33.2 – 85.1%	2, 13
Blacktip shark	<i>Carcharhinus tilstoni</i>	16	LC	Sustainable	NT	2005	53 – 82%	3, 14
Sandbar shark	<i>Carcharhinus plumbeus</i>	16	NT	Recoveringw/Undefined ^e	VU	2007	16.9 – 62.7%	4, 9, 10, 11
Scalloped hammerhead shark	<i>Sphyrna lewini</i>	15	EN	Depleted	CR	2018	54.1 – 91.4%	3, 4, 6, 9, 10, 11
Spinner shark	<i>Carcharhinus brevipinna</i>	13	LC	Sustainable	NT	2005	81.3 – 96.9%	4, 10
Silky shark	<i>Carcharhinus falciformis</i>	10	NT	Sustainable	VU	2017	42.2 – 66.3%	1, 6, 9, 10
Pigeye shark	<i>Carcharhinus amboinensis</i>	9	LC	Sustainable	DD	2005	n/a	
White shark*	<i>Carcharodon carcharias</i>	6	VU	Recovering	VU	2018	49.2%	13
Green sawfish shark*	<i>Pristis zijsron</i>	5	CR	Depleted	CR	2012	n/a	
Blacktip reef shark	<i>Carcharhinus melanopterus</i>	3	LC	Sustainable	NT	2005	n/a	
School shark*	<i>Galeorhinus galeus</i>	3	VU	Depleted	VU	2006	72.7%	2
Smooth hammerhead shark	<i>Sphyrna zygena</i>	3	NT	Sustainable	VU	2018	62 – 71%	6, 8
Zebra shark	<i>Stegostoma fasciatum</i>	3	LC	Sustainable	EN	2015	0%	3
Dwarf sawfish shark*	<i>Pristis clavata</i>	2	EN	Depleted	EN	2012	n/a	
Blue shark	<i>Prionace glauca</i>	1	NT	Sustainable	NT	2018	14.3 – 22.6%	5, 6, 7, 9
Grey nurse shark*	<i>Carcharias taurus</i>	1	CR ^e /NT ^w	Depleted ^e /Sustainable ^w	CR ^e / NT ^w	2003	41.3%	13
Porbeagle shark	<i>Lamna nasus</i>	1	NT	Sustainable	VU	2018	21.4 - 43.8%	5, 7, 9
Shortfin mako shark	<i>Isurus oxyrinchus</i>	1	VU	Depleting	EN	2004	21.3 – 35.6%	5, 6, 7, 9

^e Eastern Australian population or stock

^w Western Australian population or stock

* Nationally protected species from recreational fishing

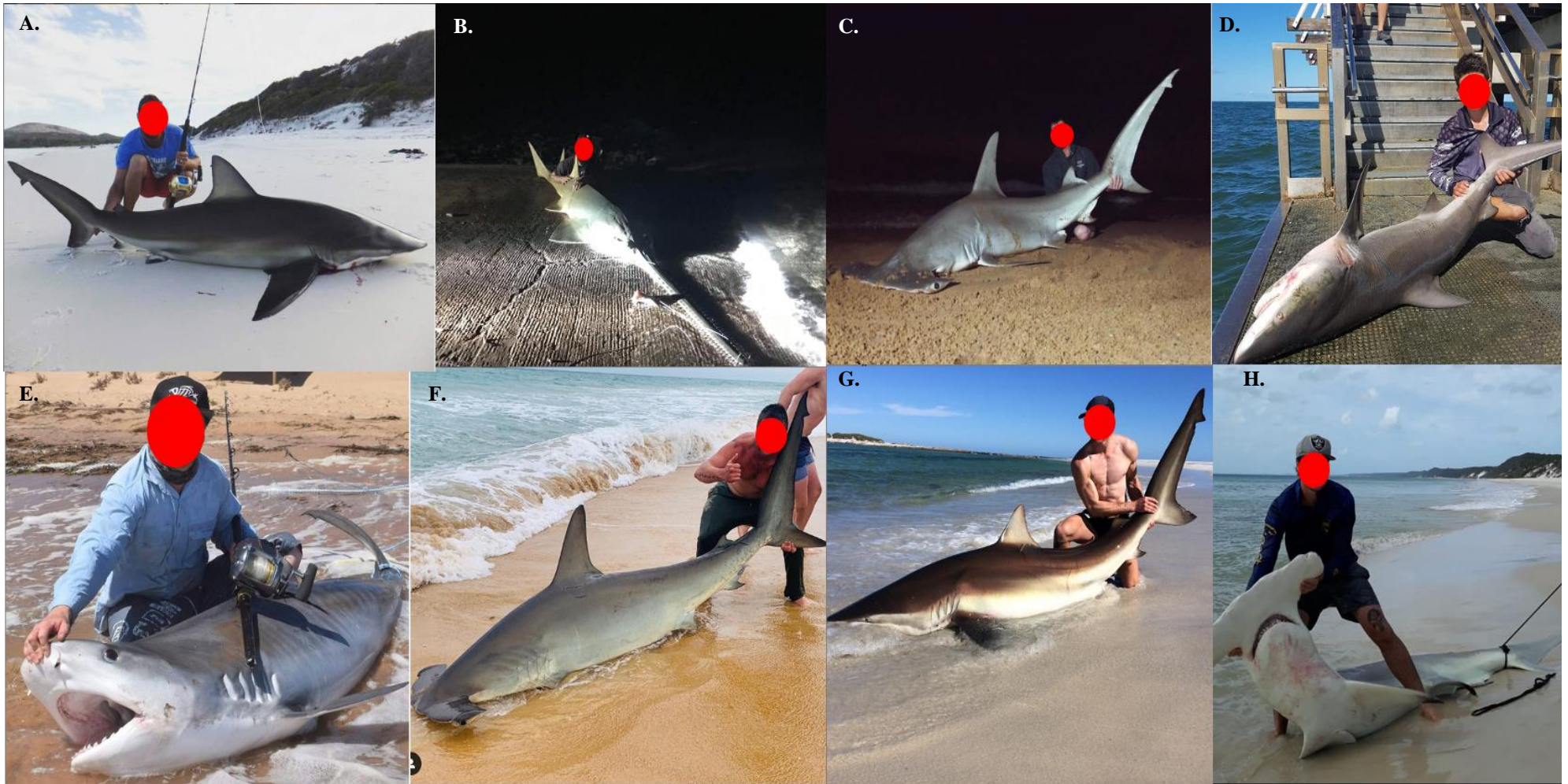


Figure 3: Representative photos (with faces obscured) of sharks landed and not landed. Sharks completely and unequivocally out of the water; A) bronze whaler, B) sawfish, C) hammerhead & D) bull. Sharks not unequivocally completely out of the water; E) tiger, F) hammerhead, G) bronze whaler & H) hammerhead.

DISCUSSION

Our study suggests that recreational fishing of elasmobranchs from land-based locations around Australia is likely to be higher than previously reported, consistent with the results from Shiffman et al. (2017). Our study also suggests that respondents regularly catch sharks from land-based locations, even if not directly targeting them. These outcomes are evident from both the survey responses and the images collected from social media. The images provide clear evidence of recreational fishers targeting sharks from predominantly beach locations and this result is supported by the survey responses. Given the frequency with which respondents that target sharks reported going fishing and that the number of images collected from social media were limited due to privacy concerns, the overall number of sharks caught annually is likely to be much higher than the number reported in national statistics (Woodhams and Harte, 2018). Most concerning, of the species reported as having been caught by land-based angling respondents and identified from social media images, a large proportion are classified as Threatened and Near Threatened according to the International Union for Conservation of Nature (IUCN, 2020).

Recreational anglers indicated that they almost always practice catch and release when fishing for sharks. However, the impact of recreational fishing on shark populations is likely to be significant given the mounting peer-reviewed evidence of detrimental post-release impacts on sharks (Arlinghaus et al., 2007; Brooks et al., 2012; Gallagher et al., 2014; Lynch et al., 2010; Shiffman et al., 2014; Skomal and Mandelman, 2012). Hammerhead sharks, which are widely recognised to be significantly more vulnerable to physiological stress and mortality resulting from capture (Gallagher et al., 2014; Morgan and Burgess, 2007), were regularly caught by anglers in our study. This is especially alarming given their conservation status: great hammerhead (Critically Endangered); scalloped hammerhead (Critically Endangered); and smooth hammerhead (Vulnerable) (IUCN, 2020). Overall, for the species regularly observed in our study, estimates of at-vessel mortality in commercial longline fisheries have a median value between 35% and 74% (Table 3). Even the low mortality rates such as those for tiger and bull sharks may have an impact on their populations and consequent ecological roles given, they are both classified as Near Threatened and were the most frequently caught species. This suggests that even a seemingly “tolerant” species may not be immune to the overall impact of recreational catch and release fishing. Our findings indicate that land-based recreational shark fishing represents a large and growing risk to already vulnerable shark populations. Specific

research is needed to assess physiological effects resulting from recreational gear and land-based fishing, as these differentiating factors have been understudied and may require alternate management practices (Ellis et al., 2017; Gallagher et al., 2015).

Results from the questionnaire survey demonstrated that recreational shark fishers had positive beliefs and attitudes toward sharks, shark value, survival and conservation. They overwhelmingly agreed with statements regarding the necessity of releasing sharks in a good condition, minimising damage and promoting survivorship. They also agreed with statements concerning the positive value of sharks and the importance of populations for healthy marine ecosystems. These responses are similar to those reported in other studies involving recreational anglers and their views on sharks (Lynch et al., 2010; McClellan et al., 2016). The respondents' positive attitudes and the indication that they would be willing to adopt and use different tackle and handling practices to minimise damage and injury to the sharks, provides encouragement that altering fishers' practices to minimise recreational fishing impact on sharks holds potential (Arlinghaus et al., 2007; Lynch et al., 2010).

Despite the positive attitudes among respondents towards shark survival and ecological importance, angler behaviour did not necessarily follow 'best practices' guidelines for handling and releasing sharks. These guidelines make recommendations to promote post-release survival of sharks which usually encourage short fight times, the use of hooks that reduce injury (e.g. circle hooks), minimal handling and the release of the shark without landing or removing it from the water (Gallagher et al., 2017). However, results indicated that anglers frequently landed sharks, removed a large number from the water and fight times were largely lengthy. The very low use of circle hooks is of concern given that hook type and by extension anatomical hooking location are important determinants of post-release morality (Carruthers et al., 2009). Additionally, in order to take "trophy" photos, anglers demonstrated the use of rough and unnecessary handling which can cause serious injury by tearing connective tissue which loosely holds their internal organs in place or by straining tendons which stabilise their vertebrae (Pepperell, 2005). These findings reveal inconsistent adherence to important guidelines that promote post-release survival of sharks. The differences between angler attitudes and behaviours might be explained by cognitive dissonance, where your behaviours contradict your beliefs (Festinger, 1957). Moreover, this situation may be exacerbated by the limited information available to recreational anglers nationally. Only two (Queensland and South Australia) out of the seven Australian state and territory government websites provide

accessible guidelines that outline handling procedures for recreational anglers targeting sharks, and only South Australia discusses gear restrictions and is specific to shore-based fishing (DAFQLD, 2013; PIRSA, 2019).

The desire revealed by respondents to ensure post-release survival of sharks combined with their inconsistent adherence to optimal survival guidelines suggests that uptake of good catch-and-release practices holds potential, but that information detailing the practices must be better disseminated. Given the relatively recent apparent increase in recreational anglers targeting sharks from shore, there may be a lag or disconnect between the available fishing information that describes the ‘best practices’ and the angler’s actions. Recreational anglers access information about fishing from a wide variety of sources and preferentially trust information provided by other anglers and strongly prefer the internet as their primary source of information (Baker, 2017; Gray and Jordan, 2010; Miles et al., 2015). This has implications as to its perceived value and reliability of the provider of the information and angler trust in these different sources may also affect their willingness to adhere to the recommendations.

The recent and rapid development of the internet, electronic media resources and online platforms (e.g. forums, blogs, social media) has provided users with an opportunity to interact and actively contribute to content and scientific discussion. However, this has concurrently provided a base for the denial of well-established scientific findings, simply by giving a stage to contrarian comments. Lewandowsky et al. (2019) illustrated that a readers’ perception of social consensus of an online post (i.e. whether the comments accepted or rejected the contents of a post) shaped their own personal belief. Thus, a small fraction of anonymous contributors with dissenting views can profoundly alter public opinion regarding controversial issues, undermining support for authentic scientific information. Within the context of the recreational angling community, the views of the more committed, active and vocal members have the ability to sway majority opinion, contrary to science. Even if new evidence brings to light the harmfulness of ongoing practices, the community’s ability to accept and implement changes can be impeded by specific members. Such positioning is concerning given that recreational fishing groups are increasingly visible in the policy arena but what they advocate for may be neither the opinion of the majority nor backed by evidence. Acknowledging the potential of this perceived consensus to shift individuals’ attitudes and change community opinions on controversial topics presents the possibility for scientists to use it in the positive promotion of scientific causes. Social media in particular, provides a powerful tool to communicate this

scientific consensus and deliver conservation messages to a wider audience, reaching all important groups; journalists, policy makers and the general public (Darling et al., 2013; Parsons et al., 2014; Shiffman, 2020).

Popular and mass media also play a critical role in presenting knowledge to the community and framing environmental issues. The information portrayed is often limited and sensationalised in an attempt to improve readership, which ultimately sways the public's acceptance of important issues and hinders management efforts (Sullivan et al., 2019). The framing of issues, setting of agendas and amplification of risk by media can shape public understanding, emotional experiences, risk level perception and influence political decisions and conservation initiatives (Sabatier and Huveneers, 2018). Additionally, the presence and overrepresentation of contrarian voices, which is common in media discourse, can also prevent the public from fully acquiring scientific consensus (Lewandowsky et al., 2019b). The media often portrays sharks negatively, using dramatic headlines, emotive language and imagery that exaggerates and distorts the story (Simmons and Mehmet, 2018). Low probability high consequence shark-human interactions attract substantial media attention and usually evoke dramatic emotional responses from the public, amplifying fear and the perception of threat from sharks. If several events occur in quick succession, this intensifies coverage and exaggerates public anxiety (Sabatier and Huveneers, 2018). The perception of risk to the public can influence policy makers to introduce management actions targeted at killing sharks (McCagh et al., 2015), by invoking fear instigated by the 1975 Hollywood film 'Jaws' depicting a man-eating white pointer (Neff, 2015). Media coverage also tends to focus on a few 'dangerous' species, responsible for the most shark-human interactions whilst ignoring their conservation statuses (Muter et al., 2013). This taxonomic bias can have a disproportionate impact on these species, weakening public awareness of species at-risk of extinction and undermining overall conservation efforts. This may explain why anglers targeted and caught far more tiger and bull sharks compared to other species, as they are commonly implicated in shark attacks on humans (International Shark Attack File, 2020). This situation is further exacerbated by an increase in anecdotal reports in the media of shark depredation giving rise to unsubstantiated claims of shark population increases (ABC, 2018; Kagi, 2016; Mercer, 2015). Intense and emotive media coverage of shark-human interactions coupled with assertions of 'out of control' populations, fuelled by depredation frustration generally leads to negative attitudes towards sharks, reducing public support for conservation and in some cases inciting opposition (Hughes and Nichols, 2020). The negative perception

surrounding sharks may provide justification for these recreational anglers to target them as entertainment narratives and government organisations frequently employ lethal solutions to eliminate the ‘so called’ threat (Neff, 2015). In order to counteract these effects, scientists need a strong and effective communication strategy and to be proactive in interacting with and providing scientifically based information to the media. Identifying and developing relationships with good environmental reporters in Florida, USA was critical to the success and effective communication of solutions aimed at reducing mortality for threatened shark species (Shiffman, 2020). By sharing information in positive ways, coordinated with current research to maintain scientific accuracy and efficacy of content, scientists can reduce overall fear and improve public awareness (Sabatier and Huveneers, 2018).

This general, mostly educational approach of improving angler behaviour assumes the main problem is the lack of understanding and knowledge of environmental issues (Mannheim et al., 2018). Although environmental literacy is important it has become evident that one sided approaches like this, rarely work on their own and do not necessarily lead to improved attitudes and pro-environmental behaviour (Kollmuss and Agyeman, 2010; Stern, 2000). Instead, it is increasingly recognised that a suite of internal (emotions and values) and external (e.g. politico-economic and socio-cultural) factors influence behaviour and that the most effective intervention programs are aimed at a combination of these factors (Gifford, 2014). Understanding the relationships between angler beliefs and behaviours is an important step in gaining insight into the driving factors behind behaviours and is particularly crucial in being able to accurately customise interventions (Heard et al., 2016). Mannheim et al. (2018) was able to show successful improvement of catch-and-release practices within a competitive shore-based angling league by using strategic interventions based on long-term observation and understanding of their behaviours. However, the authors acknowledged that the overall success of the interventions was based on the development of trust between the scientists and the anglers as this was deterministic in the implementation of community wide behavioural changes (Mannheim et al., 2018). In angling communities like the one in this study, in which these relationships can be distrustful and acrimonious, scientists could instead develop relationships with conservation-conscious and well-respected anglers within the community that act as leaders, championing improved behaviours (Mannheim et al., 2018). This may also have the indirect effect of altering social norms within the community, which can bring about the desired behavioural changes as individuals are more likely to change their behaviour in response to perceived social pressure influencing recreational anglers’ compliance (Heard et

al., 2016; Lubchenco et al., 2016; Thomas et al., 2016). Management strategies should therefore aim to incorporate human characteristics and promote voluntary acceptance of regulations, as these non-force compliance methods hold promise in situations where traditional regulations and enforcement efforts are limited (Cooke et al., 2013).

Limitations

The methods used in this current study present logistical and feasible ways of studying a geographically widespread and diverse community that may be difficult to identify and contact directly. However, future research of this community should consider the potential limitations of using these approaches. While the survey plan was to obtain a national distribution of responses across states and territories, demographics and experience levels, sampling bias may have affected the results. The dominant ages and genders within the group sampled might not have been reflective of the broader recreational fishing community and be overly representative of those who use social media. Additionally, the interest and support (in the form of reposting of the survey) from several specific WA Facebook groups may have led to an increased proportion of WA participants, skewing the national distribution. Privacy concerns and ethical procedures also limited the scope of this investigation as only publicly available information was accessed on social media. Future research into land-based recreational shark fishing could use different methods to investigate the scale of the activity, using for example thermographic remote cameras which have been shown to provide an effective method of assessing 24 hour recreational fishing effort in small- to medium-sized geographical areas (Taylor et al., 2018). These cameras present an alternative cost-effective strategy for sampling, particularly as a large proportion of angler's target sharks during crepuscular or nocturnal periods. The tendency of anglers to post only their 'best catch' online may present bias in the representation of species and size. This is likely further confounded by specific species' behaviour, habitat preferences and ecological distributions. For example, blacktip sharks *C. limbatus* have recently been shown to flee to shallow water when confronted by great hammerhead sharks *S. mokarran* (Doan & Kajiura 2020) and lemon sharks *Negaprion* spp. have a greater nearshore distribution and demonstrate a high degree of site fidelity (Danylchuk et al., 2014). These factors may influence catches by making specific species more accessible to recreational anglers and disposed to catch-and-release fishing and should be included in future investigations. Additionally, the collection of accurate species-specific catch information may have been limited by anglers' ability to distinguish between various species. However, Gibson et al. (2019) was able to demonstrate that participants in a shark fishing competition did have the

ability to identify sharks with relatively low error so this may not present an issue for experienced anglers directly targeting sharks. Finally, desirability bias may have influenced anglers' responses to belief statements as respondents answer contrary to their actual beliefs to represent themselves in the most socially acceptable way. The possibility of perceived social norms influencing survey responses must be considered in future studies as these could potentially invalidate results.

Conclusion

This study is the first investigation of recreational land-based shark fishing in Australia and provides evidence that this group of recreational anglers catch a substantial number of Threatened and Near Threatened shark species. The analysis of images collected from social media and the distribution of a national online recreational fishing survey via social media enabled an assessment of this previously 'cryptic' activity. The findings illustrate a clear disconnect between angler beliefs and their behaviours, as they possess strong positive attitudes towards sharks and shark conservation but demonstrate actions to the contrary. By acknowledging that the media plays a large and deterministic role in how sharks are portrayed to the public, scientists can work with, and provide information to reporters and journalists to reduce fear and increase public awareness. Further exploration of the relationship between angler beliefs and behaviours, has potential to help future management initiatives in inciting effective and long-lasting changes, that reduce the threat to these already at-risk shark species. Future research should also be directed at determining post-release morality and non-lethal effects of sharks from recreational gear and land-based activities, to provide evidence for scientific messages that support behavioural interventions directed at recreational land-based anglers.

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Supplementary Information 1

Questionnaire Survey

The following questions formed the national recreational shark fishing survey. The survey targeted recreational anglers around Australia and aimed to develop an understanding of their perceptions, practices, motivations and opinions surrounding sharks and shark fishing.

Section 1: General fishing questions (Adapted from McClellan et al. (2016))

1. Approximately how many years have you been fishing?
 - a. <1 year
 - b. 1-5 years
 - c. 5-10 years
 - d. 10-20 years
 - e. 20+ years

2. Approximately how often do you fish?
 - a. Everyday
 - b. Once a week
 - c. Once a fortnight
 - d. Once a month
 - e. Once a year

3. On a scale of 1 to 5 (1 = least important and 5 = most important): How important would you rate fishing as part of your lifestyle?
 - a. 1
 - b. 2
 - c. 3
 - d. 4
 - e. 5

Section 2: Encounters/interactions with sharks

4. When you fish, do you ever target sharks?
 - a. Yes
 - b. No

If answer is a. then skip to question 5

- 4.1. When you fish, do you ever catch sharks accidentally/incidentally?
 - a. Yes
 - b. No

If answer is b. then skip to question 30

5. How often do you fish for sharks?

- a. Less than once a year
- b. 1-5 times a year
- c. 6-10 times a year
- d. 11-20 times a year
- e. 21-50 times a year
- f. 51-100 times a year
- g. Every time I fish

6. What species or types of shark do you most often target?

Participants to choose from photos with species IDs.

7. What are the main reasons that you target sharks?

- a. To eat for food
- b. Fishing competitions
- c. Excitement/thrill of the catch
- d. Satisfaction of catching the largest fish
- e. Opportunity to interact with the large marine predators

8. What time of the day do you normally go shark fishing? (Choose one):

- a. Midnight – 4am
- b. 5am – 12pm
- c. 1pm - 5pm
- d. 6pm - 11pm

9. In what months of the year do you normally go shark fishing? (Choose all applicable months):

- a. January
- b. February
- c. March
- d. April
- e. May
- f. June
- g. July
- h. August
- i. September
- j. October
- k. November
- l. December

10. Which state/territory do you mostly go shark fishing in Australia?:

- a. ACT
- b. NSW
- c. SA
- d. NT

e. TAS

g. WA

f. VIC

h. QLD

11. Have you ever caught a shark?

a. Yes

b. No

12. Have you caught a shark in the last three months?

a. Yes

b. No

If answer is b. skip to question 30.

Section 3: Shark fishing techniques (Adapted from McClellan et al. (2016))

For the following questions, please recall as much information as possible about your most recent shark catch.

13. What was the species/type of shark you caught?

Participants choose from photos with species IDs.

14. What was the approximate size of the shark (please indicate units of measurement)?

15. Where did you catch the shark (approximate geographic location or point of interest)?

Participants choose location on an interactive google map

16. Were you land-based fishing or boat-based fishing when you caught the shark?

a. Land-based

b. Boat-based

If answer is b. then skip to question 21

17. Where were you land-based fishing when you caught the shark?

a. Coastal waters

d. River

b. Bay

e. Estuary

c. Inlet

18. What type of land-based fishing site did you catch the shark from?:
- a. Beach
 - b. Pier
 - c. Jetty
 - d. Bridge
 - e. Bank
19. Did you land the shark? (Bring the shark onto land)
- a. Yes
 - b. No
20. If yes, approximately how long did it take you to land the shark?
- a. <1 min
 - b. 1-5 min
 - c. 6-10 min
 - d. 11-20 min
 - e. 21-30 min
 - f. 31-60 min
 - g. 1-2 hrs
 - h. >2 hrs
 - i. I don't know/
remember
21. What type of fishing gear did you use to catch the shark? To the best of your ability, describe the type of fishing gear that you used in the following categories:
- a. Rod/pole
 - b. Line/leader
 - c. Hook
 - d. Bait or lure
 - e. Other
22. Was the shark alive or dead?
- a. Alive
 - b. Dead
23. Where was the hook located?
- a. Mouth
 - b. Stomach
 - c. Throat
 - d. Gills
 - e. Snout
 - f. Upper Jaw
 - g. Cheek
 - h. I don't know/ remember
 - i. Other (please specify)
24. Was the shark kept or released?

a. Kept

b. Released

If answered a. skip to question 26.

If answered b. complete question 25.

If answered c. skip to question 27.

25. If released, what is the reason for releasing the shark? (Choose one or more of the following):

- a. I always practice catch and release when fishing for sharks
- b. I was not trying to catch a shark (bycatch)
- c. I consider the shark to have important ecological value
- d. I consider the shark inedible or I don't eat shark
- e. The shark was not of the legal-size limit
- f. I already reached my possession or bag limit
- g. I couldn't identify the species
- h. The shark had no value to me
- i. Other (please specify)

Skip to question 30

26. If kept, what was the reason for keeping the shark? (Choose one or more of the following):

- a. It was more convenient than release
- b. I believe the shark won't survive release
- c. To reduce the number of sharks in the ocean (cull)
- d. I consider the shark to be edible/ I will eat the shark
- e. To show my friends and/or family
- f. To weigh and measure the shark for a fishing competition
- g. Other (please specify)

27. Was the shark taken out of the water?

a. Yes

b. No

28. How long was the shark out of the water? Please give your best estimate.

- a. < 1 min
- b. 1-5 min
- c. 6-10 min
- d. 10-30 min
- e. 30 min +

29. Was the hook removed?

- a. Yes
- b. No

Section 4: Knowledge about sharks

30. Do you think sharks important for the functioning of the marine ecosystems? (Choose one):

- a. Yes
- b. No

31. Do you think shark populations are: (Choose one):

- c. Increasing
- d. Decreasing
- e. Stable

32. How many species of sharks do you think there are? (Choose one):

- a. 1-50
- b. 51-100
- c. 101-200
- d. 201-400
- e. 400+

33. Do you think sharks produce more offspring than other marine fish? (Choose one):

- a. Yes
- b. No

Section 5: Opinions on sharks and shark fishing (Adapted from Lynch et al. (2010))

For the questions on this page, rate your agreement with the following statements (Strongly Agree, Somewhat Agree, Neither Agree nor Disagree, Somewhat Disagree, Strongly Disagree)

34. Catching sharks

- a. Catching a shark adds to the enjoyment of my fishing trip

- b. I prefer to catch fish rather than sharks
- c. Sharks are good to eat
- d. I enjoy the challenge of catching a shark
- e. Catching a shark wastes my fishing time
- f. I target sharks when I go fishing
- g. Sharks are a threat to other fish I want to catch

35. Catch and release

- a. I like to ensure that a shark is released in good condition
- b. It does not matter to me whether a shark survives after I release it back into the ocean
- c. The landing of the shark has an impact on the survival of the shark after release
- d. I would be willing to use tackle and special handling practices that minimizes damage to released sharks and improves its chances of survival
- e. It is important that all the sharks I release survive

36. Value of sharks

- a. It is important to have viable populations of sharks
- b. It would be better and safer if there were fewer sharks in the ocean
- c. Sharks are of little use or importance to humans
- d. Sharks are a sign of a healthy marine ecosystem
- e. I enjoy seeing sharks in the ocean
- f. Sharks are an irrelevant part of the ecosystem
- g. Sharks should be conserved as they have a right to exist

37. Threats to sharks

- a. Recreational fishing does not affect the health of shark populations
- b. Commercial fishing is a threat to shark populations
- c. Sharks need to be protected
- d. Climate change poses the greatest threat to sharks

38. Management

- a. Current management measures and restrictions conserve sharks

- b. More regulations are required for recreational fishing of sharks
- c. Current management restrictions are too strict and/or interfere with my fishing

39. Please rank the following management options with regard to shark conservation based on your willingness to adopt them.

(1 = most willing, 5 = least willing)

- a. Seasonal restrictions
- b. Size limits
- c. Area restrictions
- d. Gear restrictions
- e. Means of deployment (Kayaking bait from shore, chumming etc)

Section 6: Demographic Questions

40. Are you male or female?

- a. Male
- b. female

41. What is your age bracket?:

- | | |
|----------|----------|
| a. <18 | e. 41-50 |
| b. 18-20 | f. 51-60 |
| c. 21-30 | g. 61-70 |
| d. 31-40 | h. 71+ |

42. Which state/territory do you live in Australia?

- | | |
|--------|--------|
| a. ACT | e. TAS |
| b. NSW | f. VIC |
| c. SA | g. WA |
| d. NT | h. QLD |

43. What is your post code?

44. What is your highest level of education?:

- a. Less than a high school degree

- b. High school degree or equivalent
- c. Trade or apprenticeship
- d. Undergraduate bachelor's degree
- e. Post-graduate degree (Honours, Masters, PhD etc)

45. What is your employment status?

- a. Full time
- b. Part time
- c. Casual
- d. Self-employed
- e. Student
- f. Unemployed
- g. Retired
- h. Pensioner

Supplementary Information 2

This “Participant Information Form” was provided to potential participants prior to their commencement of the online recreational shark fishing survey. Participants were required to download the document and read and understand its contents before electronically providing their consent by clicking agree to the following statements:

- I have read and understood the information provided in the Participant Information Form.
- I voluntarily agree to participate
- I am 18 years or older



School of Biological Sciences,
The University of Western Australia
35 Stirling Highway, Crawley WA
6009

Participant Information Form

Project title: Understanding Land-Based Trophy Shark Fishing in Australia to improve long-term sustainability

Name of Researchers:

This study is being conducted by a research student at the University of Western Australia, as part of the requirements of a Master’s degree. It is being supervised by Professor J. Meeuwig and Professor D. Zeller, of the School of Biological Sciences at the University of Western Australia.

Invitation:

You are invited to participate in this research study investigating land-based recreational shark fishing in Australia. Through this questionnaire survey, the research team seeks to gain insight into the knowledge, attitudes, motivations and practices of land-based recreational shark anglers. The questionnaire is being promoted through social media, discussion forums and other websites to invite anglers with an interest in shark fishing to help us develop an understanding of the characteristics of this particular fishing activity and its participants. Before you decide whether or not to take part, please take time to read the following information which explains why this research is being done and what would be your involvement.

Aim of the Study (What is the project about?)

Land-based shark fishing is a catch and release activity which involves anglers directly targeting large sharks from the beach or jetties. This type of fishing has had a significant

increase in popularity in recent years and could have negative impacts on individual sharks and consequently their populations given that a number of these species are considered globally threatened. However, the risk posed by this recreational activity is difficult to assess as there is no available information due its non-compulsory reporting. This project therefore seeks to (1) determine the scale of the activity, (2) assess the risk to threatened shark populations and (3) develop an understanding of the perceptions, practices and motivations of the anglers. This questionnaire will be used to investigate the latter, by asking questions that seek to evaluate angler knowledge, opinions and actions with respect to land-based trophy shark fishing in Australia.

What does participation involve?

As part of the study we ask you to fill in an online questionnaire via the online survey host *Qualtrics*. You will be able to take part anywhere that you have access to the internet and complete the questions at a time suitable to you. We expect the questionnaire to take between 15-20 minutes.

Voluntary Participation and Withdrawal from the Study

Participation in this study is completely anonymous and voluntary. It is entirely your decision whether or not you decide to take part. If you don't understand the information included in this document you should discuss your participation in this survey with someone you trust, who is able to support you in making the decision.

You can withdraw from the survey PRIOR to submission of the questionnaire. However, as this questionnaire is completed anonymously, once you have completed and submitted your questionnaire it will NOT be possible to retrieve your specific questionnaire. We will not be able to identify your specific questionnaire. There will be no consequences associated should you choose to withdraw.

Your privacy

Completion of the survey is done anonymously. All information will be collected and securely stored to protect your privacy. The research data will be kept on the UWA Institutional Research Data Store (IRDS) for a minimum of 7 years. The storage facility has secure access which will only be available to the research team.

On completion of the questionnaire, you will be asked if you would like to be included in our prize draw, for a chance to win one of four \$50 BCF vouchers. If you would like to be included, we will ask you to provide an email address to contact you if successful. Any survey with an email address supplied will be de-identified, that is, your survey will not be linked to or re-identifiable by your email address. You should know that if your email address contains your name, then anonymity cannot be guaranteed as the researcher may become aware of your name during the prize draw. However, to ensure you remain anonymous and your survey data is protected the email addresses will only be seen by one member of the research team to draw the four prize winners, after which they will all be permanently deleted.

Possible Benefits

There are unlikely to be direct personal benefits to you from this study. Some people enjoy participating in this kind of research, welcoming the opportunity to give their views on a

particular subject; in this case, land-based recreational shark fishing. Participants will be able to follow the study and read the findings in the published master's thesis paper.

The information gained from this questionnaire will provide some insight into the practices and perceptions of land-based recreational shark anglers in Australia and the overall findings from the study may provide additional information to improve the overall conservation and management of shark species in Australian waters.

Possible Risks and Risk Management Plan

The time it takes to complete the survey may inconvenience you if done in one sitting, so the survey can be saved and completed over a number of sessions if required.

Completion of the survey is done anonymously. Only if you choose to disclose your own involvement, will others become aware of your participation.

Lottery Draw

On completion of the survey you will have the chance to enter your email to go into the draw to win one of 4 x \$50 BCF vouchers.

Contacts

If you would like to participate or discuss any aspect of this study, please feel free to contact the research team via the Facebook page RecSharkFishingAus or 20754979@student.uwa.edu.au.

Sincerely,
Chief Investigator

Approval to conduct this research has been provided by the University of Western Australia, in accordance with its ethics review and approval procedures. Any person considering participation in this research project, or agreeing to participate, may raise any questions or issues with the researchers at any time. In addition, any person not satisfied with the response of researchers may raise ethics issues or concerns, and may make any complaints about this research project by contacting the Human Ethics office at UWA on (08) 6488 4703 or by emailing to humanethics@uwa.edu.au. All research participants are entitled to retain a copy of any Participant Information Form and/or Participant Consent Form relating to this research project.

Supplementary Information 3

Screen shot of the Facebook page that was created to promote the recreational shark fishing survey on social media.

The screenshot shows the Facebook page for 'Recreational Shark Fishing Survey Australia'. The page header includes the name and a search bar. The cover photo features a shark on a fishing line with the text 'DO YOU FISH FOR SHARKS?' and 'HAVE YOU EVER CAUGHT A SHARK?'. The profile picture is a circular image of a shark. The left sidebar contains navigation options: Home, Posts, Reviews, Photos, About, Community, and Groups, along with a 'Create a Page' button. The main content area shows a post from January 15 with the text: 'Do you catch sharks? Have you ever caught a shark? Tell us about your experience by completing a short survey. You could WIN 1 of 10 \$50 BCF vouchers!!! 🎉👏 ... See More'. The right sidebar includes a 'Send Message' button, a 'No Rating Yet' section, a 'Community' section with '37 people like this' and '39 people follow this', an 'About' section with a link 'bit.ly/2sb4c8d' and categories 'Science, Technology & Engineering', 'Impressum', and 'Suggest Edits', and a 'Page Transparency' section stating 'Page created - December 10, 2019'.

Flyer for the recreational shark fishing survey which was used on social media to promote the survey nationally around Australia.

DO YOU FISH FOR SHARKS?

HAVE YOU EVER CAUGHT A SHARK?

TELL US ABOUT YOUR EXPERIENCE BY COMPLETING A SHORT SURVEY!

What's the purpose of the study?
This survey is being used to gain insight into the knowledge, attitudes, motivations and practices of land-based recreational shark anglers around Australia.

Who can participate?
This study seeks participants who are 18 years and older, who have experience fishing and catching sharks.

How do I get involved?
To complete the survey, please go to:
<https://bit.ly/2sb4c8d>
or scan the QR code:



What's involved?
Participation involves the completion of a short online survey, taking between 15 - 20 minutes.



WIN 1 of 10 \$50 BCF GIFT VOUCHERS!

Any questions
VISIT: facebook.com/recsharkfishingsurveyaus
or EMAIL: recsharkfishingsurveyaus@gmail.com



THE UNIVERSITY OF WESTERN AUSTRALIA

Example image of the Facebook advertising campaign that targeted recreational anglers nationally around Australia.

 **Recreational Shark Fishing Survey Australia**
Sponsored · 

Tell us about your experience by completing the survey.
Chance to WIN 1 of 10 \$50 BCF gift cards!



UWA.QUALTRICS.COM
WIN \$50 BCF GIFT CARD

[Learn More](#)