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A characterization of Australian shortfin mako shark anglers

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ABSTRACT

Understanding the human dimensions of recreational fisheries is critical to the development of effective fisheries management regulations. This study aimed to characterize Australian shortfin mako shark (Isurus oxyrinchus) anglers in terms of their gear use, perceptions on circle hooks, perceptions on sharks and shark conservation, and attitudes towards fisheries management. A targeted web survey was completed by 272 shortfin mako anglers distributed across southeastern Australia. Responses were compared across angler subgroups in relation to their state of residence, membership to an angling club, and tendency to release or keep captured sharks. Overall, anglers' perceptions about how their fishing behaviours and gear choices may affect the survival of released shortfin mako sharks were quite in line with existing scientific knowledge though anglers believed their behaviours have less of an impact on shark stocks than other threats such as commercial fisheries. Gear selection was determined largely by fishing preference (harvest or catch-and-release) of the angler, with those practicing catch-and-release more frequently using circle hooks. State of residence also influenced the perceptions of anglers towards sharks and shark survival as well as their attitudes towards fisheries management. Angler support for precautionary management suggests that a better understanding of the potential impacts of recreational fishing on shark stocks may assist in promoting greater accountability and responsible fishing practices amongst these resource users; however, improved communication between recreational fishers, management authorities, and fisheries scientists is a necessary precursor to this step.

1. Introduction

Psychological characteristics such as attitudes, perceptions, and beliefs can play a large part in how individuals participate in a fishery [1–3]. These characteristics can be shaped by peer-peer interaction [4], so affiliation with a fishing club for example can influence an individual's engagement within a fishery [5]. Angling clubs also attract members with more experience, who fish more frequently, and are more specialized than non-members [6]. Other factors such as fishing preferences (whether they harvest or release fish), or cultural norms can also influence participation within a fishery and opinions on fisheries management [7,8]. Fishery participation can be complicated further in the context of shark fisheries, where elements of fear and negativity may reduce public support for shark conservation or even incite opposition to it [9–11]. Conservation behaviour as simple as adherence to recommended best-practice fishing techniques (see Ref. [12]) can help to minimise incidental fishing mortality in fisheries, however, even avid anglers with many years of fishing experience may not be familiar with

these recommendations [2]. Additionally, the potential magnitude of recreational catches and the vulnerability of many species to fishing pressure may not be realised by anglers [13]. This lack of recognition could feed beliefs that there is little need for shark conservation or management measures amongst recreational resource users [14,15], particularly if these measures decrease their catch success [16]. Frequent positive interactions are needed between anglers, scientists and fisheries managers to ensure trust and cooperation between these groups and compliance with fisheries regulations [1,17,18]. Consequently, there is a need to understand the current beliefs, perceptions, and attitudes towards management and conservation and the factors that contribute to these psychological characteristics before any attempts to move forward with the cooperation of anglers can be made [1].

Throughout the world, there now exists a large body of research concerning catch-and-release angling in recreational fisheries (see Ref. [19] for review). Although fishing methods, gears, and sensitivity of the target species to post-release mortality varies across fisheries, some

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general guidelines for improving catch welfare have been developed that apply to most recreational fisheries [12,20]. In most instances, sublethal consequences and post-release mortality can be linked to physical injuries associated with the gear used and the handling of the animal (e.g.: [21–23]). The most common relationship in all of these studies is the association between post-release mortality and the occurrence of deep hooking [16,24]. Deep hooking is characterized by hook penetration of sensitive tissues beyond the mouth cavity such as the oesophagus, gills and organs that often results in severe blood loss [25–28]. This is an important issue when considering the effects of recreational fisheries that release a substantial proportion of captured fish. Restricting the type of hooks that anglers can use (e.g. single vs. treble hook, barbed vs. barbless, circle vs. J hook, and sizes) is often the most effective means of reducing the incidence of deep hooking and mortality [16,24,84].

The effect of hook type on hooking location and subsequent survival has been well documented in both commercial [29-32] and recreational studies [33-37]. Although exceptions exist, most comparisons between standard J hooks and circle hooks reveal the latter to reduce deep hooking and increase the survivorship of released individuals [21,29,30,34,35,38,39]. It should be noted that although circle hooks are generally better for fish welfare, offsetting circle hooks are typically less effective at decreasing deep hooking and subsequent mortality [30,38,40]. While some commercial operations are now required to use circle hooks as standard practice [41], the overall frequency of their use in recreational fisheries is still unknown. It is relevant to understand the gear currently used by recreational fishers and any factors that may influence the uptake of more responsible gears such as circle hooks. These factors include awareness of these alternative gears, as well as angler attitudes and perceptions on proposed benefits and potential drawbacks [2,16].

In Australia, the shortfin mako shark (Isurus oxyrinchus) is targeted for both consumption and catch-and-release by recreational anglers. It is, however, prohibited to be retained if retrieved live during commercial operations. Furthermore, commercial operators are limited in the number of sharks they can legally retain each trip [42]. While bag limits for sharks do apply to recreational anglers throughout Australia, the number of anglers fishing for sharks, their effort, and hence, the total annual mortality attributed to recreational fishing is unknown and largely unmonitored. Although the status of Australian mako shark populations is uncertain, the species has suffered dramatic declines across parts of its range due to fishing [43-45] and many anglers now practice catch-and-release despite regulations allowing for harvest [46]. A recent Australian survey indicated that approximately 55% of tournament anglers practice catch-and-release when targeting pelagic sharks, however less than half of these anglers reported using circle hooks [47], which is likely to have implications for the survival of released individuals [22,30]. The reasons for low circle hook adoption amongst these anglers are currently unknown. Additionally, no published information is currently available for gear use by non-tournament fishers, which likely constitutes the majority of the users of this resource (authors pers obs).

This study aims to characterize shortfin mako shark anglers from three Australian states. Our study aims to address the gear usage of shortfin mako shark anglers, explore anglers' psychological characteristics surrounding gear choices, shark conservation, and fisheries management and the relationships between these characteristics and factors such as state of residence, affiliation with a fishing club, and the angler's preference to release or harvest sharks.

2. Methods

2.1. Survey distribution

A structured web-based questionnaire was designed and distributed using the online platform 'Survey Monkey'. The questionnaire was pilot

tested with a small group of experienced recreational fishers to refine questionnaire structure, flow, and address potential misunderstandings or ambiguities in the questions prior to its implementation. The final questionnaire was made accessible to the public between May-September 2014. It was promoted via various angling web forums (three based in Tasmania, two in Victoria and two in New South Wales [NSW]), social media pages associated with game fishing, and participating game fishing clubs (promotional information and instructions were sent to club presidents and secretaries belonging to Game Fishing Association of Australia (GFAA) registered clubs in the three states). The survey was also promoted by game fishing celebrities through social media. The chance to win a fishing reel was provided to respondents as incentive to complete the questionnaire. The survey distribution involved strategic targeting and self-selection (nonprobabilistic) sampling which includes inherent limitations (reviewed in Ref. [48]). Nonetheless, this approach is common in the social sciences as well as in the fisheries literature (e.g. Refs. [16,49,50]), and is appropriate for obtaining information on sensitive issues from informed and experienced users [51].

2.2. Questionnaire design

The self-administered questionnaire was separated into four sections; 'gear use and perception of circle hooks', 'perceptions of sharks and shark survival', 'environmental attitudes and fisheries management', and 'demographics'. The survey also included three additional sections that were part of a separate study but administered within the same questionnaire; 'fishing behaviour and motivations', 'catch-andrelease preferences', and 'specialisation and consumptive orientation' [46]. The sections relevant to the current study are explained in more detail below. All questions related to perceptions and attitude offered the response "unsure/don't know", but these responses were excluded from analysis. The full survey including the cover letter (Appendix 2) and questions (Appendix 3) can be found in appendices.

2.3. Gear use and perceptions on circle hooks (Questionnaire Section D)

Respondents were asked how often they used various gears (J hook, J hook-offset, circle hook, circle hook-offset, tail rope, tag pole, and gaff), when they expected to either release (Questionnaire Section D3) or keep (Questionnaire Section D4) sharks. Tail ropes are a method used for landing sharks once close to the angler. A pole is fitted with a slip loop off one end which is placed around the caudal fin of the shark. When the angler pulls on the pole, the loop cinches and the shark can be landed tail first. Responses available ranged along a five-point Likerttype scale ranging from "never" (1) to "always" (5). Before answering these questions, respondents were asked a filtering question (Questionnaire Section C1); "Please indicate which of the following best describes your fishing method: 1. I release all of the mako sharks I catch, 2. I mainly practise voluntary catch and release fishing, but will retain the occasional mako, 3. I practise voluntary catch and release and harvest fishing equally for make sharks, 4. I mainly keep makes, but will voluntarily practise catch and release on occasion. 5. I never release a mako shark unless I have to". Those who answered "1" were only asked how often they used certain gears when targeting sharks to release (Questionnaire Section D3), those who answered "5" were offered the same questions in relation to keeping sharks (Questionnaire Section D4), and those who answered "2", "3", "4" were offered both sets of questions.

The section also evaluated perceptions regarding circle hooks (Questionnaire Section D2). Anglers were asked to rate their agreement with 13 statements about circle hooks related to shark welfare, catch rates, and preference of using circle hooks, along a five-point scale ranging from "strongly agree" (5) to "strongly disagree" (1). All respondents were asked to answer Questionnaire Section D2 regardless of their answer to the filtering question (Questionnaire Section C1).

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2.4. Perceptions of sharks and shark survival (Questionnaire Section E)

This section asked questions regarding a respondent's perceptions on sharks and shark survival. In Questionnaire Section E1 respondents were asked to indicate what they believed the likelihood of survival would be for a mako shark caught and released under nine different conditions. Responses were rated on a five-point scale ranging from "almost certainly survive" (1), "likely to survive" (2), "50/50 chance" (3), "likely won't survive" (4) and "almost certainly won't survive" (5).

In Questionnaire Section E2, respondents were asked their level of agreement with seven general statements about impacts of fishing and mako shark populations. Responses were structured around a five-point scale of "strongly agree" (5), "agree" (4), "neutral" (3), "disagree" (2), and "strongly disagree" (1).

2.5. Environmental attitudes and fisheries management (Questionnaire Section F)

This section explored respondents' attitudes towards fisheries management and threats to Australian mako shark populations. Questionnaire Section F1 asked for respondents' level of agreement with eight hypothetical management options to regulate recreational fishing for mako sharks based on a five-point scale ranging from "strongly agree" (5) to "strongly disagree" (1). Questionnaire Section F2 investigated potential reasons that management regulations may not be adhered to by rating agreement with eight statements. In Questionnaire Section F3, respondents were asked what they believed the level of threat was of various items (e.g. global warming, lack of science in management) to Australian mako shark stocks. Responses were structured around a five-point scale ranging of "a serious threat, large changes are needed" (5), "a threat, needs better management" (4), "somewhat of a threat, current management is effective" (3), "slight threat, should be monitored" (2), and "not a threat at all" (1). Finally, Ouestionnaire Section F4 investigated respondents' agreement with eight statements that reflected their personal beliefs towards the regulation of game fishing in their state. Responses varied along a fivepoint scale ranging from "strongly agree" (5) to "strongly disagree" (1).

2.6. Demographics

Basic demographic information including the angler's state of residence and whether they belonged to a fishing club was collected for each respondent for use as independent variables in the analysis. These variables have previously been found to affect anglers' attitudes, values and behaviours [6,8].

2.7. Statistical analysis

Exploratory Factor Analysis (EFA) was conducted on the responses of all anglers to Section D2 of the questionnaire that asked them to report their level of agreement with 13 statements related to circle hook use. The EFA reduced the item space to a three-dimensional factor space. Three rotations were explored to identify a factor solution with simple structure (achieved by the "promax" rotation). Any items that were not shown to have acceptable loadings (> 0.3) on any factors were removed and the analysis was re-run without them [52].

A confirmatory factor analysis (CFA) was conducted to assess how well measured variables were represented within the three-factor solution constructed during the EFA [53,54]. Acceptable model fit was based on criteria recommended by Hu and Bentler [55] and Schreiber et al. [85]. CFA is widely used for examining relationships between Likert type variables, such as those derived from the current survey [56]. Prior to the CFA, the scale was tested for multivariate normality using the MVN package [57] and diagonally weighted least squares (DWLS) was used as an estimation method for use in the CFA [58]. Models that were shown to have an unacceptable fit to the data were discarded. The CFA model was carried out using the Lavaan package for R [59]. Factor loadings, z-values and measure of internal consistency (Cronbach's alpha or Spearman-Brown Prophecy Formula coefficients, where appropriate) are presented.

Each question within the survey (excluding demographic information) was used as a dependent variable and modeled against the independent variables of state of residence (NSW, Tasmania, Victoria), club membership, and 'fishing preference' (release most, equal, keep most). The independent variable fishing preference, was created by grouping respondents based on the response to the question "Please indicate which of the following best describes your fishing method: 1. I release all of the mako sharks I catch, 2. I mainly practise voluntary catch and release fishing, but will retain the occasional mako, 3. I practise voluntary catch and release and harvest fishing equally for mako sharks, 4. I mainly keep makos, but will voluntarily practise catch and release on occasion, 5. I never release a mako shark unless I have to" in Section C1 of the questionnaire. Anglers that responded 1 or 2 were grouped as 'release most', 3 were grouped as 'equal', and 4 or 5 were grouped as 'keep most'.

The difference in gear used when anglers targeted sharks for retention or release was examined using paired Wilcoxon tests. Gear use effects on survival, perceptions on sharks and threats to sharks, and attitudes towards fisheries management, as well as the latent factors constructed for perceptions on circle hooks, were compared between club members and non-members using independent sample Mann-Whitney U tests, and between state of residence and fishing preference using Kruskall-Wallis H tests [86]. Significant results from Kruskal-Wallis tests were followed up by pairwise comparisons with p values adjusted using the Bonferroni-Dunn method [60,61]. All statistical analyses were conducted using R [62]. Tables can be found in the Appendix and their names correspond to the questionnaire section to which they refer.

3. Results

Overall there were 272 valid questionnaires completed, including 272 based on club affiliation, 268 based on region of residence, and 246 based on fishing preference. Respondents were both affiliated (N = 107) and unaffiliated with fishing clubs (N = 165), and were distributed across NSW (N = 82), Tasmania (Tas; N = 112), and Victoria (Vic; N = 74). Most respondents were classified as 'release most' (N = 173), with fewer classified as 'equal' (N = 30) or 'keep most' (N = 43) for the constructed variable fishing preference. All respondents were male and ranged from 13 to 70 years of age. Results tables for questionnaire sections can be found in Appendix 1.

3.1. Gear use

The prevalence of gears used when sharks were targeted for retention (N = 223) was significantly different to those used when sharks were targeted for release (N = 186, all p < 0.01). For instance, J hooks (M = 2.82, p < 0.01) and offset J hooks (M = 2.17, p < 0.01) were more commonly used when keeping sharks than releasing, while circle hooks (M = 3.19, p < 0.01) and offset circle hooks (M = 2.52, p < 0.01) were more commonly used when releasing sharks than keeping. Tail ropes were mostly used when releasing sharks for retention (M = 4.15) and rarely used when releasing sharks (M = 2.44, p < 0.01). A gaff was used most often when anglers targeted sharks for retention (M = 4.16) but was rarely used when anglers targeted sharks for catch-and-release (M = 1.95, p < 0.01; Table D, Fig. 1).

With a few exceptions, there was no significant difference in gear use between state, club membership, and fishing preference groups when targeting sharks for release (N = 223) or retention (N = 186). Exceptions include anglers from NSW who reported more frequent use of circle hooks (N = 61, M = 3.65) for catch-and-release fishing than anglers from Victoria (N = 68, M = 3.07, p = 0.04) and Tasmania



Fig. 1. Comparison of gear use (mean \pm SD of the distributions) when anglers targeted mako sharks for retention (N = 186) or release (N = 223). Mean and standard deviation values are based on response codes for always (5), mostly (4), sometimes (3), rarely (2) and never (1). Asterisks denote a statistically significant difference between groups when assessed using paired Wilcoxon tests (p < 0.05).

(N = 91, M = 2.95, p < 0.01). 'Release most' anglers also reported a higher frequency of circle hook use during catch-and-release fishing (N = 158, M = 3.37) compared to 'keep most' anglers (N = 38, M = 2.74, p = 0.02). 'Keep most' anglers (N = 38, M = 2.89) were significantly more likely to use J hooks during catch-and-release fishing than 'release most' anglers (N = 158, M = 2.26, p = 0.01). Non-club members (N = 130, M = 1.72) used offset J hooks less commonly than club members (N = 93, M = 2.05; p = 0.01) for catch-and-release fishing, although both groups used this gear rarely (Table D3). When retaining sharks, no significant differences in gear use were reported across state (N = 183), club membership (N = 186), or fishing preference groups (N = 186; Table D4).

3.2. Perceptions on circle hooks

The three factors in the EFA model on circle hook perceptions were summarized as 'Benefits accruing to the sharks', 'Negative effects on catch rates' and 'Negative effects on angling experience'. The model yielded an acceptable fit when tested using CFA (Table 1), and only two items were omitted during model development. Anglers (N = 223) had

Table 1

Resulting factor analysis featuring angler's perceptions on circle hook use. Mean range is based on response codes for strongly agree (5), agree (4), neutral (3), disagree (2), and strongly disagree (1). Means, medians, and standard deviations for each factor reflect the overall statistic for the remaining items within each factor. Cronbach's alpha (α) and Spearman-Brown Prophecy Formula (SB) coefficients are included as measures of internal consistency. CFA fit indices: (n = 182, χ 2 = 24.90, p = 0.98, df = 41, CFI = 1.00, RMSEA < 0.01, SRMR = 0.05).

Best Model	Mean	Median	SD	Standardised Factor Loading	z value
Benefits accruing to the sharks ($\alpha = 0.80$)	4.01	4	0.71		
Using circle hooks, rather than J hooks, increases the likelihood of a shark surviving once released.	4.22	5	0.95	0.83	13.55
Circle hooks cause less damage to the shark compared to J hooks.	4.12	4	0.99	0.72	12.30
Use of circle hooks decreases foul hooking in sharks, including gut hooks.	4.18	4	0.91	0.71	11.84
Using circle hooks, rather than J hooks, reduces the chance of dropping a shark once it is hooked.	3.63	4	1.03	0.58	11.15
I know how to use circle hooks correctly when fishing for sharks.	3.88	4	0.89	0.46	10.22
Negative effects on catch rates ($\alpha = 0.88$)	2.46	2	0.91		
Using circle hooks decreases hook-up rates.	2.57	2	1.07	0.95	17.88
Using circle hooks makes it harder to hook-up.	2.67	3	1.09	0.84	16.69
Using circle hooks decreases catch rates.	2.40	2	1.05	0.77	15.65
Using circle hooks decreases the likelihood of catching a shark.	2.20	2	0.99	0.69	14.84
Negative effects on angling experience (SB = 0.84)	2.14	2	0.89		
Using circle hooks makes fishing for makos too hard compared to using J hooks.	2.30	2	0.98	0.89	12.00
Using circle hooks makes fishing less enjoyable.	1.98	2	0.94	0.82	12.00



Angling circumstance

Fig. 2. Means and standard deviations of the rating scale used to estimate the likelihood of shark mortality under different circumstances of capture. Mean and standard deviation is based on response codes for almost certainly survive (1), likely to survive (2), 50/50 chance (3), likely won't survive (4) and almost certainly won't survive (5). Responses for "unsure/don't know" were omitted prior to analysis.

high overall mean agreement (M = 4.01) with items within 'Benefits accruing to the sharks', particularly that they increase the likelihood of shark survival relative to J hooks (M = 4.22), decrease foul hooking, including gut hooks (M = 4.18), and cause less damage to the shark (M = 4.12). The overall mean agreements for items listed within the factors 'Negative effects on catch rates' (M = 2.46) and 'Negative effects on angling experience' (M = 2.14) were low. There were no significant differences in these factors across states (N = 221) or club membership (N = 223; all p > 0.05). However, the factor 'Negative effects on angling experience' did vary by fishing preference, with 'release most' anglers (N = 157, M = 1.97) disagreeing with this factor significantly more than 'keep most' anglers (N = 40, M = 2.25).

3.3. Effect on survival

Collectively, anglers (N = 223) assigned a lower chance of survival to sharks that were bleeding heavily (M = 3.92), gaffed (M = 3.74), and non-responsive (M = 3.62), relative to sharks that had been on the line for a long time (M = 2.78), had been brought on deck (M = 2.64), and had external injuries from the trace (M = 2.52; Fig. 2). Some perceptions on shark survival varied by state with NSW anglers

(N = 62, M = 3.25) assigning a 50:50 likelihood of a gill-hooked shark surviving after release while Victorian anglers (N = 68, M = 3.74) tended to rate the item closer to "likely won't survive" (p < 0.01). Anglers from Tasmania (N = 91, M = 2.87) also rated the likelihood of survival as "will likely survive" for a shark that had its tail wrapped in the trace and was pulled in backwards, while both NSW (N = 62, M = 3.41, p < 0.01) and Victorian anglers (N = 68, M = 3.42, p < 0.01) rated this item closer to "likely won't survive". Club members (N = 93, M = 2.96) also thought that sharks subjected to this treatment would be more likely to survive than non-members did (N = 130, M = 3.36, p = 0.01). Additionally, club members (N = 93, M = 2.91) were more likely to expect a shark to survive long fight times compared to non-members (N = 130, M = 2.59, p < 0.01; Table E1).

3.4. Perceptions on sharks and threats to shark populations

Respondents (N = 223) expressed strongest disagreement with the statement "Outside of fishing, I believe mako sharks are a danger to people" (M = 1.63) followed by the statements "mako shark populations are able to recover quickly from overfishing" (M = 2.13), and "I believe my personal fishing activities can have an impact on mako shark stocks" (M = 2.46). In contrast, the greatest agreement was associated with the statements "I would not fish for mako sharks if I thought it was not sustainable" (M = 4.01) and "I regularly take steps to minimise my impact on shark stocks" (M = 3.89; Table E2).

Significant differences in perceptions existed between states (N = 223) regarding sharks and shark conservation. NSW respondents (N = 62, M = 2.09) had significantly greater disagreement with the statement "I believe my personal fishing activities can have an impact on mako shark stocks" than both Victorian (N = 68, M = 2.71, p < 0.01) and Tasmanian (N = 91, M = 2.70, p < 0.01) respondents. NSW respondents (M = 2.72) had significantly greater disagreement with the statement "I believe recreational fishing can have an impact on mako shark stocks", than Tasmanian respondents (M = 3.31, p = 0.02). NSW respondents (M = 4.15) expressed greater agreement than Victorian respondents (M = 3.61) with the statement "I regularly take steps to minimise my impact on shark stocks" (p < 0.01), while 'release most' anglers (N = 157, M = 4.11) expressed significantly more agreement with this statement than 'keep most' anglers (N = 40, M = 3.05, p < 0.01). 'Keep most' anglers (M = 3.33) had significantly greater agreement with the statement "I only see mako sharks as a source of sport or food" relative to 'equal' anglers (release and keep equally; M = 2.50, p = 0.04), or 'release most' anglers (M = 2.63, p < 0.01; Table E2).

Mean scores of perceived threats to mako shark populations (N = 218), were greatest for commercial fisheries bycatch and discards (M = 3.97) which was considered "a threat, needs better management". The loss of prey species (M = 3.15), lack of science in management (M = 2.95), pollution (M = 2.66), and lack of appropriate management (M = 2.90) were considered "somewhat of a threat, current management is ineffective", while anglers generally reported global warming (M = 2.17) and recreational fishing (M = 2.08) as a "slight threat, should be monitored". Tasmanian anglers (N = 89, M = 2.34) rated recreational fishing significantly more of a threat to make populations relative to both Victorian (N = 66, M = 1.95, p = 0.05) and NSW anglers (N = 61, M = 1.86, p < 0.01). Club members (N = 92) assigned a significantly higher threat rating than non-members (N = 126) to commercial fishing by catch and discards (M = 4.15 vs. 3.84, p = 0.04) and a significantly lower threat rating to global warming (M = 1.91 vs. 2.36, p = 0.01; Table F3).

3.5. Perceptions on fisheries management in Australia

The strongest agreement received from respondents (N = 218) was in relation to the statement "I believe that fisheries management is needed to keep fisheries sustainable" (M = 4.39), this was followed by

agreement for "Regulations are not enforced enough" (M = 3.81), and "In the face of limited scientific knowledge about fish stocks, management should be precautionary" (M = 3.64). Tasmanian anglers (N = 89, M = 3.16) reported significantly less agreement with the statement "I think that fisheries management is often used as a tool of "the green movement" relative to NSW anglers (N = 61, M = 3.83, p < 0.01). NSW anglers (N = 61, M = 2.79) had less agreement with the statement "Current fisheries regulations are generally based on reliable science", compared to respondents from both Victoria (N = 66, M = 3.34, p < 0.01) and Tasmania (N = 89, M = 3.37, p < 0.01). Club members (N = 92, M = 2.95) expressed significantly more disagreement relative to non-members (N = 126, M = 3.25) with the statement "The reasons for regulations are generally communicated in an easy to understand manner" (p = 0.03). There was also a significant difference in agreement with the statement "Regulations are not enforced enough", between 'release most' anglers (N = 155, M = 3.95) and 'keep most' anglers (N = 38, M = 3.34, p < 0.01; Table F4).

Regarding the reasons that anglers (N = 218) may not follow fisheries regulations, respondents expressed the highest agreement with the statements "commercial fishing takes too many sharks" (M = 3.98), "regulations that force me to release all mako sharks I catch will still result in some of these sharks dying; which would be a waste of the resource" (M = 3.83), "I do not think enough is currently known about Australian make populations to form effective regulations" (M = 3.53) and "Recreational fishing has little effect on the mako shark population" (M = 3.35). Anglers from NSW (N = 61) rated significantly higher agreement than Tasmanian anglers (N = 91) with the statements "Regulations are not needed because populations of mako sharks are not in trouble" (M = 3.03 vs. 2.53, p = 0.02), "Commercial fishing takes too many sharks" (M = 4.29 vs. 3.73, p < 0.01), "Recreational fishing has little effect on the mako shark population" (M = 3.71 vs. 3.12, p < 0.01, "Current levels of catch-and-release fishing conserve stocks without need for additional regulations" (M = 3.52 vs. 2.95, p < 0.01), "I do not have much trust in management or scientific advice" (M = 2.80 vs. 2.28, p = 0.02), and "I do not think enough is currently known about Australian mako populations to form effective regulations" (M = 3.80 vs. 3.26, p = 0.01). Victorian anglers (N = 66, M = 4.07) had significantly greater agreement with the statement "Regulations that force me to release all mako sharks I catch will still result in some of these sharks dying; which would be a waste of the resource" than NSW anglers (M = 3.55, p < 0.01). Similarly, club members (N = 92) rated significantly greater agreement than nonmembers (N = 126), for regulations not being followed because they believed "not enough is currently known about Australian mako populations to form effective regulations" (M = 3.72 vs. 3.39, p = 0.03), "that populations of mako shark are not in trouble" (M = 2.90 vs. M = 2.64, p = 0.05), and that they "do not have much trust in management or scientific advice" (M = 2.76 vs. 2.37, p = 0.01); although the latter two of these statements were still rated as slight disagreement. No significant differences of opinion were observed between fishing preference groups (Table F2).

The hypothetical management regulation that had most agreement from respondents (N = 218) was "a season possession limit of mako shark per person per year" (M = 3.63), this was followed in support by "minimum size limits on mako sharks" (M = 3.59), and "maximum size limits on mako sharks" (M = 3.51), and "mandatory use of circle hooks to reduce hooking damage in sharks" (M = 3.47, Table F1). The least popular (greatest opposition) hypothetical management regulation was "mako sharks to be strictly catch-and-release only" (M = 2.23). This was followed in unpopularity by having "closed seasons for fishing mako sharks" (M = 2.80), and "a limited number of 'permit to keep' tags, sold by government each year to ensure that recreational catches are capped" (M = 2.86). 'Release most' anglers (N = 155, M = 2.42) were significantly more likely to support mandatory catch-and-release than 'keep most' anglers (N = 38, M = 1.89, p = 0.02) and 'equal' anglers (keep and release equally; N = 25, M = 1.60, p < 0.01), however



Hypothetical management regulation

Fig. 3. Respondents opinions on hypothetical management regulations in relation to their fishing preference. 'C&R only' refers to a regulation that permits only catch-and-release of mako sharks. Means and standard deviations are based on response codes strongly agree (5), agree (4), neutral (3), disagree (2), and strongly disagree (1). Means sharing the same letter do not differ significantly between fishing preference groups (p < 0.05).

all groups still expressed overall disagreement with this proposed regulation (Fig. 3). 'Release most' anglers were also significantly more likely to support maximum size limits than 'keep most' anglers (M = 3.70 vs. 3.11, p = 0.03), closed seasons than 'equal' anglers (M = 2.90 vs. 2.12, p < 0.01), and mandatory use of circle hooks compared to 'equal' anglers (M = 3.70 vs. 2.96, p = 0.01) and 'keep most' anglers (M = 3.70 vs. 2.87, p < 0.01). Club members (N = 92) showed significantly less agreement with maximum size limits (M = 3.28 vs. 3.68, p = 0.02) and closed seasons (M = 2.51 vs. 3.02,p < 0.01) relative to non-members (N = 126). Tasmanian (N = 91, M = 4.09) respondents reported significantly more agreement with season possession limits than Victorian (N = 66, M = 3.26, p < 0.01) and NSW respondents (N = 61, M = 3.35, p < 0.01), and more agreement with closed seasons (M = 3.09 vs. 2.57, p = 0.04), and permit to keep tags relative to respondents from Victoria (M = 3.15 vs. 2.56, p = 0.04, Table F1).

4. Discussion

This study has characterized Australian shortfin make shark anglers in terms of their gear use, perceptions on circle hook use, sharks, and shark survival, and attitudes towards fisheries management. Differences in psychological characteristics across angler subgroups related to club membership, state of residence, and fishing preference were explored to better understand the practices and choices of anglers who participate in this fishery. Selection of gear was shown to be determined largely by the fishing preference of the angler, with those practicing catch-andrelease more frequently using circle hooks. Region of residence was also related to the perceptions and behaviours of fishers with the largest differences being noted between respondents from NSW and Tasmania. Some differences existed between club and non-club members, but this characteristic had less of a relationship with gear choices, perceptions on the impacts of shark fishing, and attitudes towards fisheries management. This work provides important context for fisheries managers on fishing behaviours, preferences, and perceptions of anglers that can be used to inform the future design of fisheries regulations.

4.1. Beliefs about shark survival and relation to gear use

Overall respondents indicated that they believed sustaining body

lacerations from the trace, being brought on deck, and being played on the line for a long duration were the least likely of the presented scenarios to result in post release mortality, and that under these situations sharks were believed to have a higher than 50:50 chance at survival. Interestingly, long fight times were rated significantly less detrimental for a shark's welfare by club members when compared with nonmembers. This may be related to differing practices between club members and non-members, where the former can be expected to play sharks on the line for longer periods, particularly when tournament rules specify lighter gauge line must be used [63]. Current research indicates that long fight times and time out of water can reduce the chance of a fish surviving [20,64].

Anglers consistently believed that sharks that were bleeding heavily, hooked in the gills, and those that appeared non-responsive boat-side were unlikely to survive. Heavy bleeding and damaged gills caused by hooking has been previously associated with post-release mortality in a number of fishes, including shortfin mako shark [21-23,30]. For shortfin mako, evidence exists to show that much of this hooking damage may be reduced through use of circle hooks [22,30]. When targeting shortfin mako for catch-and-release, circle hooks were the most commonly used hook type, although overall, most anglers reported using this gear less frequently than "mostly". Circle hook use during catch-and-release fishing was significantly lower amongst Tasmanian and Victorian respondents compared with their NSW counterparts. Anglers from NSW also reported the highest agreement with the statement "I regularly take steps to minimise my impact on shark stocks" and least agreement with the statement "recreational fishing can have an impact on shark stocks" which are both consistent with the fact that NSW anglers have the highest adoption of circle hooks. Contrastingly, when sharks were targeted for retention, circle and J hooks were utilised almost equally with anglers rating the average frequency of circle hook use less often than "sometimes". This indicates that a portion of game fishers are voluntarily selecting specific gears (i.e circle hooks) to improve the welfare of sharks they intend to release, but have a greater reliance on other hook types (e.g. J hooks) when they intend to keep their catch. These findings appear to confirm that to some degree, hook selection corresponds with fishing motive as well as behavioural norms [65]; for example, fishers that more routinely practice catch-and-release will be more likely to use circle hooks.

Respondents perceptions of circle hook use would have suggested higher use of this gear amongst these respondents. The benefits for survival of using circle hooks for catch-and-release of shortfin mako is a belief generally held by anglers, though the adoption of this hook style was reported to be used less frequently than "mostly" even when catchand-release fishing. These findings agree with recent research that has found a disconnect with the desire to promote released shark welfare and a lack of adherence to best-practice recommendations [2]. The beliefs or perceptions of anglers regarding the effectiveness and usability of gears can prove to be a great barrier to their adoption into common use [16]. Cooke et al. [16] also identified that the most common challenges facing circle hook use were associated with existing angler beliefs that the gear is ineffective at capture and that circle hooks are difficult to use. Data in the current study contrasts those findings as most anglers agreed that they knew how to use circle hooks correctly when fishing for sharks and disagreed that using circle hooks made fishing for mako sharks too hard compared to using J hooks. Based on current angler perceptions, it seems likely that most anglers would be willing to adopt circle hooks into common use, or at least that behavioural norms where circle hooks are used may be established through better promotion by outdoor media outlets and tackle shops [16].

4.2. Perceptions on sharks and threats to shark populations

Anglers expressed awareness that stocks are not able to recover quickly from overfishing, but tended to disagree that their personal fishing behaviours impacted make shark stocks. Anglers typically agreed that they would not fish for mako sharks if they thought the activity was unsustainable. Anglers likely attributed the possibility of overfishing to commercial fisheries as anglers believed commercial fishing bycatch and discards was the most serious threat to mako shark populations. Although the individual impact of a single recreational angler may be minimal, it is the collective impact of all anglers that may have population/ecosystem level impacts [66-71] which may not be recognized by the individual. Indeed, Australian mako shark anglers tended to list recreational fisheries as a slight threat to shark stocks. A lack of accountability for ecosystem effects caused by personal fishing behaviours has also been noted amongst saltwater anglers in the United States [15]. It is somewhat striking that despite how similar the broader impacts of commercial and recreational fishing are [68], the perceived impacts that these two sectors pose to shark stocks has been rated so differently by anglers. Self-exclusion and blame displacement (denial) are not uncommon amongst resource users as individuals attempt to protect their self interests and sense of well-being [72,73]. Identifying and managing denial amongst recreational fishers will be an important step to constructive decision-making and management of the mako shark resource.

4.3. Perceptions on management and support for regulations

The support of anglers is often required to implement effective fisheries regulations [17,74]. Overall, respondents expressed agreement for the need for fisheries management authorities to keep fisheries sustainable and indicated that more enforcement of fisheries regulations was necessary. However, respondents suggested that they may not follow regulations based on the belief that their own impacts are insignificant in comparison to those of the commercial sector. Conflict between these fishing sectors has been reported for the last few decades in Australia [75] and is likely continuing due to the influence of Australia's angling lobbyists that have been generally successful at focusing on the threats of commercial fisheries rather than also acknowledging that recreational fishing has impacts (discussed in Ref. [70]). These conflicts can be problematic for adherence to current fisheries regulations and emphasize the point that common issues must be identified between the two sectors so that unified conservation and management actions can be taken on the resource [11,68]. Although recreational anglers tended to share perceptions towards fisheries management and threats to mako sharks, interesting differences were present amongst anglers across regions.

Anglers from NSW expressed the highest agreement for all potential reasons that regulations may not be followed, except that regulations are too confusing, and that post-release mortality is a waste of the resource. NSW anglers also indicated that they do not believe current regulations are based on reliable science, and had the least trust in fisheries management, despite recreational fishing regulations being fundamentally similar between all three states [76-78]. Although not significantly different to the other two states, NSW anglers expressed the least agreement with the statement "The reasons for regulations are generally communicated in an easy to understand manner" which may help explain why this group were generally less supportive of fisheries management relative to anglers from the other two states. Previous studies have highlighted anglers' limited understanding of, and support for, fisheries regulations stemming from poor communication between management agencies and the public [3], with most information being spread by word of mouth between anglers [1,79]. Effective communication may be best achieved by actively integrating recreational fishers in the science-support [80] and decision-making process [81] and failure to do so may contribute to opposition to conservation efforts and incite conflict between managers and resource users [18].

When asked for their agreement of hypothetical management measures for recreational shortfin mako fishing, respondents agreed most with seasonal possession limits on the numbers of mako shark per person per year, while opposing mandatory catch-and-release and regulations that limit their current fishing opportunities. Seasonal possession limits allow anglers the option to retain and restrict harvest without compromising fishing access. Release-oriented anglers tended to have the greatest agreement with hypothetical regulations. Similarly, non-consumption-oriented anglers in Germany tended to support habitat management strategies more so than consumption-oriented anglers [82], while Texas anglers with the greatest consumptive orientation had the least support for proposed management regulations [7]. Anglers from Tasmania were more retention-oriented and had the greatest support for seasonal possession limits, closed seasons, and permits to keep, each of which is about restricting overall take while still permitting anglers to keep sharks. It is valuable to understand which types of regulations will encounter the most resistance from anglers and which are most likely to be accepted and followed. Understanding regulation preferences across angler sub-groups may create fisheries regulations most suited to the management/legislative area of interest [82].

4.4. Conclusion

Using targeted non-probabilistic sampling, we obtained information from almost 300 self-identified shark anglers in Australia. This nonrandom approach does constrain the extent to which generalized insight can be drawn and extrapolated to the broader community [83]. Nonetheless, such sampling approaches do yield valuable information to help managers understand a component of the stakeholder community. Overall, these data indicate that with a few exceptions, anglers have generally realistic and accurate perceptions about the effect of gear choices and various capture circumstances on the survival of released shortfin mako sharks, but tend to downplay their individual impact and collective impacts of the recreational sector on shark stocks. It is interesting to note that a large proportion of anglers still utilise J hooks for both retaining and releasing sharks despite their positive perceptions of circle hooks, including their ability to reduce deep hooking and post-release mortality. The barriers to further adoption of circle hooks are unclear, but it does not appear to be related to perceived decreases in catch rates. It is suggested that greater communication between recreational fishers, management authorities and fisheries scientists will increase the use of this gear amongst fishers. Angler beliefs that fisheries management is needed to keep fisheries sustainable and support for precautionary management suggests that a better understanding of the potential impacts of recreational fishing on shortfin mako stocks may assist in promoting greater accountability and responsible fishing practices amongst these resource users.

Declarations of interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.marpol.2019.103550.

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