



RESEARCH ARTICLE



Motivation and harvesting behaviour of fishers in a specialized fishery targeting a top predator species at risk

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Abstract

1. Effective management of wildlife resources depends on understanding and cooperating with the human users of the resource, particularly as policies may be rejected if user satisfactions are not met. In Australia, recreational anglers can legally target a migratory top predator, the shortfin mako shark *Isurus oxyrinchus*, which is also a species at risk. It is assumed that most of the sharks are released and population remains minimally impacted; yet, the actual release rate of this species is unknown and little information is available about anglers that participate in this fishery.
2. Fishing motivations and behaviours were ascertained by a web survey of recreational shark anglers from three south-eastern Australian states. Respondents reported that ~70% of the captured makos were released, with significant geographic variation in release rates between states.
3. Most anglers reported being motivated by the catch-based objectives, the thrills and challenges, rather than harvest-based motivations. However, there were significant differences in harvesting motivation among states. This could be attributed to the varying value assigned to shortfin mako as a sport fish and table fish among regions. Additionally, higher rates of release among anglers from New South Wales may be linked to increased opportunity for resource substitution (i.e. greater diversity of game fish species) and established norms driven by current catch-and-release fisheries in that region.
4. Increased participation in catch-and-release fishing may be achieved by establishing behavioural norms by the provision of more desirable incentives to release sharks during fishing competitions. Data on regional variation in release rates yield important information for managers to target specialized fishers to incentivize catch-and-release fishing with an objective of changing behaviour.
5. Many anglers understand that sharks are important to marine ecosystems and messaging may be important to deliver effective management given that most anglers are motivated by catch-based objectives even though many enjoy harvesting makos. Information on natural resource user motivations and

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satisfactions, such as studied here, has the potential to guide management actions and the ways in which managers interact with resource users.

KEY WORDS

recreational fishing, human dimensions, harvest, catch-and-release, survey, species at risk

1 | INTRODUCTION

Large predators have essential roles in ecosystems including top-down effects on community composition and prey populations (Newsome et al., 2017; Ripple et al., 2014; Sergio et al., 2008). These inherently rare species tend to grow slowly, mature later in life, have relatively low fecundity, and are therefore especially vulnerable to disturbance (Purvis, Gittleman, Cowlshaw, & Mace, 2000; Ripple et al., 2014). The majesty and might of large predators renders them symbols to humans and they can serve as umbrella species (Friedrich, Jefferson, & Glegg, 2014; Kellert, Black, Rush, & Bath, 1996). Despite this, human relationships with predators is complex, and many populations have been reduced by human activities including directed persecution, habitat loss and exploitation (Estes et al., 2011; Lennox, Gallagher, Ritchie, & Cooke, 2018; Myers & Worm, 2003; Ripple et al., 2014). Top predators in the ocean, such as sharks, may be particularly cryptic given the relative inaccessibility of most of the ocean and a lack of understanding can contribute to negative perceptions that trigger persecution. Nevertheless, broad distributions within the oceans, rarity and cryptic biology render many sharks valuable to recreational diving and fishing industries and focus on sharks in conversation plans can drive top-down management practices in protected areas (Gallagher, Cooke, & Hammerschlag, 2015; Gallagher, Hammerschlag, Danylchuk, & Cooke, 2017; Giglio, Luiz, & Schiavetti, 2015; Topelko & Dearden, 2005).

Balancing the conservation needs of species at risk against the economic value that can feed back to influence their conservation is challenging (Cooke et al., 2016; Lindsey, Roulet, & Romanach, 2007; Shiffman et al., 2014). Impacts of ecotourism operations that exploit sought-after species benefit from scientific evaluation of the consequences to develop management plans that minimize impacts and maximize benefits (e.g. Ellenberg, Setiawan, Cree, Houston, & Seddon, 2007; Williams, Trites, & Bain, 2002; Griffin et al., 2017). Recreational fisheries are one industry that capitalizes on the value of charismatic species and can have impacts on individuals and populations to varying degrees (Arlinghaus et al., 2005; Cooke & Cowx, 2004; Lewin, Arlinghaus, & Mehner, 2006; McPhee, Leadbitter, & Skilleter, 2002; Post et al., 2002). For some species, recreational effort exceeds that of commercial operations, including vulnerable and high value species (Arlinghaus et al., 2005; Coleman, Figueira, Ueland, & Crowder, 2004; Lewin et al., 2006). In all recreational fisheries, there is a balance between harvesting and releasing fish that depends on local regulations and angler preferences/motivations, which is especially critical where fisheries target species of conservation concern (Cooke et al., 2016). Because there can be high degrees of heterogeneity in the motivations and

outcomes sought by anglers, recreational fisheries provide a useful venue in which to explore the dynamic relationship between stakeholders and their preferred targets (Arlinghaus et al., 2007).

Effective wildlife management not only focuses on sustaining the populations of the target species and their environment, but also understanding and cooperating with stakeholders, because policies may be ineffective without stakeholder support (Fisher, 1997; Nielsen, 1999). Understanding motivations of groups engaging in wildlife exploitation is critical in developing appropriate management and, where necessary, altering behaviour to optimize conservation benefits; in recreational fisheries, this can be the estimation of current and future catch-and-release participation rates and promotion of catch-and-release of species at risk (Frijlink, 2011; Heard, Sutton, Rogers, & Huvneers, 2016; Sutton & Ditton, 2001). An angler's decision to release fish is determined by commitment to angling (specialization), consumptive orientation and contextual factors such as the size of the fishing party, hours fished and the number of different species caught (Sutton, 2003). Specialization is comprised of subdimensional properties that relate to an angler's experience, avidity, skill and the centrality of fishing to the angler's lifestyle (Ditton, Loomis, & Choi, 1992; Salz, Loomis, & Finn, 2001). Consumptive orientation measures the importance of certain catch-related variables to the angler, namely catching numbers of fish, keeping fish, catching a trophy fish and catching something (Anderson, Ditton, & Hunt, 2007; Fedler & Ditton, 1986; Kyle, Norman, Jodice, Graefe, & Marsinko, 2007). Species must have unique value to stakeholders as food items or sport fish (Tracey, Lyle, Ewing, Hartmann, & Mapleson, 2013; Wallmo & Gentner, 2008) and may also have important conservation (Bruce, 2014; Heard et al., 2016; Jensen et al., 2009), economic (Hickley & Tompkins, 1998; Shrestha, Seidl, & Moraes, 2002; Galeano, Langenkamp, Levantis, Shafron, & Redmond, 2004; Prayaga, Rolfe, & Stoeckl, 2010; Frijlink, 2011) or social (Kellert, 1985; Neff & Yang, 2013; Philpott, 2002) attributes. Additional layers of geographic, cultural and/or social context (Graefe & Ditton, 1997; Grambsch & Fisher, 1991; Henry & Lyle, 2003; Rogers & Bailleul, 2015; Sutton, 2003) can yield important differences in attitude and behaviour towards wildlife.

Understanding the connection between human attitudes and behaviour is critical to managing socio-ecological systems, and this is a topic that is particularly relevant for shark conservation and management of industries that exploit them (Friedrich et al., 2014) study investigated recreational anglers targeting a vulnerable shark, shortfin mako *Isurus oxyrinchus* (Cailliet et al., 2009). The shortfin mako shark is a popular target of recreational fishers in both the Atlantic and Pacific Oceans and is both harvested for meat and released for

sport (Stevens, 2008; Wells & Davie, 1985). In this study the characteristics and motivations of Australian anglers were established from responses to an online survey administered to identify specialization, consumptive orientation, and motivations for catching, keeping and releasing shortfin mako sharks. Jurisdictional comparisons were made to investigate regional differences in norms. This study contributes to understanding how humans perceive predators, specifically one that is listed as vulnerable, and how the perception of the species contributes to the behaviour of the individual. Thus, findings will fill a key knowledge gap for enhancing sustainable management and conservation of predator populations at a time when there is an urgent need to understand the human dimension of such systems.

2 | METHODS

2.1 | Fishery

The shortfin mako shark is the most important target species of shark for recreational game fishers in the south-eastern states of Australia (New South Wales [NSW], Victoria [Vic], Tasmania [Tas] and South Australia [SA]; Rogers and Bailleul, 2015). It is not only targeted for its 'fighting' abilities but also coveted for consumption (Stevens, 2008; Wells & Davie, 1985). Following population declines in the northern hemisphere, the mako shark was registered as 'Vulnerable' by the International Union for Conservation of Nature (IUCN) on their Red List and 'migratory' by the Convention on the Conservation of Migratory Species (CMS). In 2010 Australia listed shortfin mako as a protected species under the Environment Protection and Biodiversity Conservation (EPBC) Act. Under this listing, it became an offence to target, catch, kill or injure this species in Australian waters. However, the listing was petitioned against by the recreational fishing sector and subsequently amendments were made to allow the species to be targeted and harvested by recreational anglers only (DEWHA, 2010). Targeted commercial fishing for shortfin mako remains prohibited in Australian waters. Management of recreational fishing in Australia is the responsibility of the States and Territories, with regulations for shortfin mako shark similar between most jurisdictions, namely a daily bag limit of one mako per person but no size limit. Core to the petitioning from the recreational sector was the argument that population-scale impacts of the recreational fishery are likely minimal and in any case most of the sharks are released (Bruce, 2014; Rogers and Bailleul, 2015). While post-release survival of line caught shortfin mako shark is high (~90%; French, Lyle, Tracey, Currie, & Semmens, 2015), assumptions about the catch-and-release behaviours of anglers require empirical data to strengthen fisheries management for this species.

2.2 | Fisher survey

A structured questionnaire was designed using the www.surveymonkey.com online platform and distributed as a web-based survey targeted at anglers who had caught and/or targeted mako sharks in the previous 12 months. The questionnaire was pilot tested with a

small group of experienced recreational fishers to refine questionnaire structure and flow and to address potential misunderstanding or ambiguities in the questions prior to its implementation.

The questionnaire was accessible online between May and September 2014 and was promoted via game-fishing web forums, social media (Facebook.com pages associated with game fishing, fisheries management and the 'post boost' function via www.facebook.com using key words such as mako shark, recreational fishing, game fishing, catch-and-release fishing) and affiliated Game Fishing Association Australia (GFAA) clubs in Tasmania, Victoria and NSW. The survey was also promoted by Australian game fishing identities via social media. A prize of fishing gear was offered as an incentive to complete the questionnaire. The 'snowball' approach adopted here comes with a number of biases but has been applied in the social sciences and fisheries literature to collect data on human dimensions (e.g. Hasler et al., 2011; Peterson & Carothers, 2013). Internet surveys are vulnerable to bias towards certain age, ethnic and socioeconomic groups (Duba & Nobile, 2010; Vaske, Jacobs, Sijtsma, & Beaman, 2011). However, given the nature of our target audience, the pool of potential respondents is inherently limited and we selected the approach because it was most likely to reach the target group in a way that would encourage participation.

2.3 | Questionnaire design

The questionnaire included three sections relevant to this study; 'catch-and-release preferences', 'specialization and consumptive orientation', and 'fishing motivation and behaviour'. The survey also included demographic profiling information and additional sections that are reported elsewhere. All questions related to perceptions and attitude offered the response 'unsure/don't know', but these responses were excluded from analysis.

2.3.1 | Fishing for makos and catch-and-release preferences

This section examined the motivations and preferences associated with fishing for mako sharks and catch-and-release behaviour. Respondents were presented with eight reasons to explain their interest in fishing for mako sharks and asked to rate each on along a five-point Likert scale of importance, with 1 = not at all important, 2 = slightly important, 3 = moderately important, 4 = important and 5 = very important. Respondents were then asked to rate which of five statements best described their fishing behaviour for mako shark. The statements included 'I release all of the mako sharks I catch', 'I mainly practise voluntary catch-and-release fishing, but will retain the occasional mako shark', 'I practise voluntary catch-and-release and harvest fishing equally for mako shark', 'I mainly keep makos, but will voluntarily practise catch-and-release fishing on occasions' and 'I never release a mako shark unless I have to'. This stated fishing behaviour is referred to as the angler's 'release philosophy' throughout this text. Anglers were then asked to rate their agreement on a five-point scale (with 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree) with six possible

reasons for releasing sharks that could have been legally retained, and six possible reasons for keeping sharks that could have been released. Respondents who indicated that they either always released or never voluntarily released their catch were only presented with the six statements applicable to their situation.

Respondents were also asked to report the total number of mako sharks caught and total number released in the previous 12 months; this response allowed comparisons to be made with their release philosophy and 'revealed' behaviour.

2.3.2 | Specialization and consumptive orientation

Specialization was measured using a scale modified from that used by Sutton and Ditton (2001) which incorporates previous experience and centrality to lifestyle components. As a measure of experience anglers were asked to estimate their fishing experience in years, the number of days they had fished in salt water in the previous 12 months and the number of days they had spent fishing for mako sharks during the same period. The measurement of centrality to lifestyle incorporated the number of subscriptions to fishing related magazines, the respondent's self-perceived skill level, the importance of fishing relative to other outdoor activities and the importance of fishing for makos relative to other types of fishing. Self-perceived skill in targeting mako sharks when compared with other game fishers was assessed on a three point scale of 0 = less skilled, 1 = equally skilled or 2 = more skilled. Importance of fishing in general and fishing for makos was assessed on a four-point scale, where 1 = the only outdoor activity/type of fishing, 2 = the most important outdoor activity/type of fishing, 3 = the second important outdoor activity/type of fishing and 4 = one of many outdoor activities/types of fishing.

Consumptive orientation was measured using a scale modified from that first utilized by Graefe (1980) and subsequently refined by others (e.g.: Sutton & Ditton, 2001; Anderson et al., 2007; Kyle et al., 2007; Frijlink, 2011). The current study omitted some repetitive questions from existing scales to form a final nine question scale. Two questions relate to 'catching something', one question to 'catching numbers', three questions to 'catching a trophy' and three questions to 'keeping the catch'. This nine-item scale was presented to respondents twice, initially worded to apply to recreational fishing in general and the second time worded specifically to apply to fishing for makos. This was done to investigate whether consumptive orientation differs between general fishing activities and the targeting of mako sharks. Respondents were asked to rate their agreement to each statement on a five-point scale (with 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree).

2.3.3 | Respondent profiling and demographics

Basic demographic information including the angler's age, gender, employment status, education status, state of residence and whether or not they belonged to a fishing club was collected for each respondent. State of residence and club membership status were used as grouping variables in the analysis.

2.4 | Analysis

2.4.1 | Creating valid scales

The scales for specialization and consumptive orientation were based on frameworks presented in Sutton and Ditton (2001). Fit of these frameworks to the data was investigated using confirmatory factor analysis (CFA; Anderson et al., 2007; Kyle et al., 2007), with an acceptable model fit based on criteria recommended by Hu and Bentler (1999) and Schreiber, Nora, Stage, Barlow, and King (2006). CFA is widely used for examining relationships between Likert-type variables (Flora & Curran, 2004). Prior to the CFA, the general and specific consumptive orientation scales were tested for multivariate normality using the MVN package (Korkmaz, Goksuluk, & Zararsiz, 2014) and subsequently diagonally weighted least squares (DWLS) was chosen as the estimation method for use in the CFA (Mindrila, 2010). The CFA model was carried out using the Lavaan package (Rosseel, 2012) in R (R Core Team, 2014). Factor loadings, z-values and measure of internal consistency (Cronbach's alpha or Spearman's coefficient where appropriate) are presented. Where an acceptable model fit was found, new parameters were created representing each dimension by averaging its constituent variables. Throughout the manuscript means are presented \pm standard deviation.

2.4.2 | Comparisons among groups

Catch-and-release behaviour, specialization, consumptive orientation, angler motivations and demographics were compared between club and non-members using independent sample non-parametric Mann-Whitney *U* tests and between states using Kruskal-Wallis *H* tests. Significant results from Kruskal-Wallis tests were followed up by pairwise comparisons with *p* values adjusted using the Bonferroni-Dunn method (Dunn, 1964; Pohlert, 2014). Paired Wilcoxon tests were used to compare angler responses between general and mako-specific consumptive orientation scales. Linear regression was used to test the relationship between the days spent fishing for mako and the percentage of sharks released. Spearman's rho was used to examine the relationship between the reported percentage of sharks released during the previous 12 months and the respondent's stated 'release philosophy' (categories range from 1 'I release all of the mako sharks I catch' to 5 'I never release a mako shark unless I have to').

3 | RESULTS

3.1 | Description of the sample population

A total of 325 survey responses were received, 2 of which were excluded because they were not completed correctly and a further 36 were excluded prior to analysis due to the respondents reporting

spending no days targeting makos and a nil catch of mako sharks in the previous 12 months. Respondents who reported not targeting makos during the previous 12 months but reported catching the species were, however, included in the analyses.

Of the 287 remaining respondents, 107 (37%) were members of fishing clubs, 165 (57%) reported having no affiliation with any fishing clubs or organizations (5% abstained). The distribution of respondents was roughly equal between NSW, Vic and Tas ($n = 82, 74$ and 112 respectively), with 4 anglers responding from SA and 15 not answering this question. SA anglers and respondents who failed to specify their location were omitted from all further comparisons by state. All respondents were male.

Fishing club members (38 ± 12 years) were significantly older than non-members (34 ± 11 years; $W = 4,568, p = 0.01$; 70 of 287 respondents abstained from providing individual demographic data;

Table S1). No significant differences in education or employment status existed between club members and non-members or between state of residence.

3.2 | Survey results

3.2.1 | Angler motivations

There were very few differences between club and non-club members regarding their interest and motivation in fishing for mako sharks therefore, they are presented together (Figure 1). Anglers reported being predominantly motivated by the catch-based experiences, especially the jumping, fighting and challenge of fishing for these large predators (Figure 1). Although it was generally reported to be less important to the fishing experience, some anglers

TABLE 1 Summary information relating to an angler's motivations for releasing mako sharks that they could have legally kept. The mean and median range are from 1 (strongly disagree) to 5 (strongly agree) with 3 representing 'neutral'

Motivations for releasing mako sharks	State/Club member	Mean	SD	Median	Kruskal-Wallis/ Mann-Whitney	<i>p</i>	Pairwise comparisons	<i>p</i>
I don't like to eat mako shark	NSW	2.65	1.28	3	H = 21.302	<0.001	NSW - Vic	0.001
	Vic	1.88	0.87	2			NSW - Tas	<0.001
	Tas	1.84	0.92	2			Vic - Tas	1.00
	Club member	2.06	1.09	2	W = 6,586	0.681		
	Not member	2.12	1.10	2				
I have already caught what I plan to eat	NSW	3.47	1.13	4	H = 3.776	0.151		
	Vic	3.71	1.18	4				
	Tas	3.78	1.05	4				
	Club member	3.79	1.04	4	W = 5,927	0.325		
	Not member	3.62	1.16	4				
I have an interest in conservation fishing	NSW	4.33	0.76	4	H = 0.682	0.711		
	Vic	4.19	0.89	4				
	Tas	4.30	0.72	4				
	Club member	4.29	0.78	4	W = 7,079	0.807		
	Not member	4.27	0.78	4				
I enjoy the sport of catch-and-release fishing	NSW	4.36	0.73	4	H = 6.882	0.032	NSW - Vic	0.079
	Vic	4.03	0.91	4			NSW - Tas	1.00
	Tas	4.36	0.73	4			Vic - Tas	0.049
	Club member	4.34	0.70	4	W = 6,733.5	0.399		
	Not member	4.22	0.85	4				
I have reached my bag/possession limit	NSW	2.73	1.40	3	H = 7.318	0.025	NSW - Vic	0.074
	Vic	3.31	1.29	3			NSW - Tas	1.000
	Tas	2.74	1.41	3			Vic - Tas	0.037
	Club member	2.81	1.48	3	W = 6,178	0.351		
	Not member	2.98	1.32	3				
I am trying to win a tag and release-based competition	NSW	3.16	1.25	3	H = 3.038	0.218		
	Vic	2.77	1.25	3				
	Tas	3.04	1.34	3				
	Club member	3.57	1.22	4	W = 2,416.5	<0.001		
	Not member	2.45	1.11	2.5				

TABLE 2 Summary information relating to an angler's motivations for keeping mako sharks. The mean and median range are from 1 (strongly disagree) to 5 (strongly agree) with 3 representing 'neutral'

Motivations for keeping mako sharks	State/Club member	Mean	SD	Median	Kruskal-Wallis/ Mann-Whitney	p	Pairwise comparisons	p		
I believe the shark will not survive release	NSW	2.81	1.37	3	H = 2.907	0.233				
	Vic	3.19	1.42	3						
	Tas	2.90	1.45	3						
	Club member	2.99	1.50	3					W = 6,434.5	0.674
	Not member	2.92	1.37	3						
I am fishing for a trophy-sized shark	NSW	2.39	1.23	2	H = 4.293	0.116				
	Vic	2.67	1.16	3						
	Tas	2.28	1.17	2						
	Club member	2.73	1.28	3					W = 4,748	0.001
	Not member	2.20	1.06	2						
I am trying to win a weight-based fishing competition	NSW	2.84	1.39	3	H = 0.941	0.624				
	Vic	2.62	1.14	2.5						
	Tas	2.65	1.28	3						
	Club member	3.09	1.30	3					W = 3,646.5	<0.001
	Not member	2.35	1.16	2						
I am fishing for food	NSW	3.03	1.32	3	H = 12.307	0.002	NSW – Vic	0.05		
	Vic	3.58	1.18	4					NSW – Tas	0.001
	Tas	3.73	1.09	4					Vic – Tas	1.00
	Club member	3.38	1.22	4					W = 6,955.5	0.254
	Not member	3.54	1.21	4						
Whenever it is legal to do so	NSW	2.11	1.11	2	H = 5.608	0.060				
	Vic	2.58	1.21	2						
	Tas	2.24	1.17	2						
	Club member	2.26	1.18	2					W = 6,266	0.674
	Not member	2.33	1.18	2						
I don't catch many mako sharks in a year	NSW	3.02	1.27	3	H = 2.176	0.336				
	Vic	3.38	1.23	3						
	Tas	3.15	1.25	3						
	Club member	2.96	1.37	3					W = 7,325.5	0.023
	Not member	3.36	1.14	4						

reported being motivated by the high quality meat of mako sharks. However, the level of motivation for harvesting mako sharks varied among states, with NSW anglers reporting less importance to the challenge of catching mako shark, the size of the shark, the quality of the flesh for eating and the satisfaction gained from weighing in a large shark than anglers from the other states. However,

There were some differences in reported motivations for keeping and/or releasing mako sharks between club and non-club members. Specifically, club members reported that they were more likely to release makos when trying to win tag and release-based competitions (Table 1) and more likely to keep mako sharks when fishing for a trophy fish and trying to win weight-based competitions (Table 2). By contrast, non-members reported that they were more likely to keep sharks because they caught very few individuals per year.

New South Wales anglers rated fishing for food as a less important motivation for keeping captured mako sharks than both Vic and Tas anglers (Table 2). Correspondingly, Vic and Tas anglers expressed more disagreement with releasing mako sharks because they do not like to eat them than did NSW anglers (Table 1). Tas anglers were also found to assign higher importance to the sport of catch-and-release fishing and lower importance to reaching bag limits as a motivation for release compared to Vic anglers (Table 1).

3.2.2 | Catch-and-release

Respondents reported catching 871 shortfin mako sharks (mean of 3 per angler) in the 12 months prior to the survey, 636 (73%) of which were released. There was some evidence for differences in mean catches among states but they were

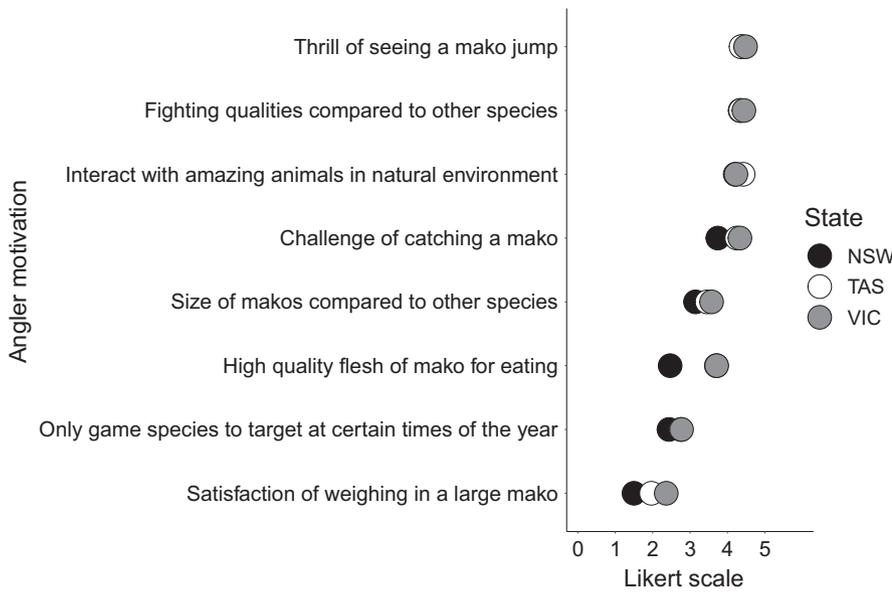


FIGURE 1 Mean responses of mako shark anglers to questions about their interest in fishing for this species based on state of residence. Motivations are described in detail in Supplementary Material but in general the y-axis can be interpreted as asking anglers to rate the importance of each aspect of the angling experience. Responses range from 1 (Not at all Important) to 5 (Very Important), with 3 representing 'Moderately Important'. Note that the mean Likert scores for motivation to harvest meat in Tas and Vic are nearly overlapping

TABLE 3 Shortfin mako shark *Isurus oxyrinchus* catch-and-release philosophy and outcomes for anglers from New South Wales, Victoria and Tasmania states of Australia. Release Philosophy was measured when respondents best described their fishing method as: 1 release all of the mako sharks I catch (1), I mainly practise catch-and-release fishing, but will retain the occasional mako (2), I practise voluntary catch-and-release fishing, and harvest fishing equally for mako sharks (3), I mainly keep makos, but will voluntarily practise catch-and-release on occasion (4), and I never release a mako shark unless I have to (5)

Catch or release parameter	State/Club member	Mean	SD	Median	Kruskal-Wallis/ Mann-Whitney	p	Pairwise comparisons	p
In the last 12 months, how many mako sharks did you personally catch, whether you kept or released them?	NSW	3.32	4.37	2	H = 4.928	0.085		
	Vic	2.27	3.26	1				
	Tas	3.11	4.20	2				
	Club member	4.07	4.62	3	W = 6,445.5	0.0001		
	Not member	2.21	3.37	1				
In the last 12 months, how many of the mako sharks that you caught did you release?	NSW	2.82	4.10	2	H = 11.978	0.002	NSW - Vic	0.0016
	Vic	1.32	2.34	0			NSW - Tas	0.174
	Tas	2.15	3.69	1	Vic - Tas	0.187		
	Club member	2.95	4.01	2	W = 6,645	0.0003		
	Not member	1.59	3.07	1				
Percentage of sharks released	NSW	82.35	30.69	100	H = 26.563	<0.0001	NSW - Vic	<0.0001
	Vic	50.73	39.02	50			NSW - Tas	<0.0001
	Tas	58.99	38.36	66.67	Vic - Tas	0.85		
	Club member	67.18	34.63	79.29	W = 4,896.5	0.800		
	Not member	62.34	40.67	75				
Release philosophy	NSW	1.88	0.85	2	H = 40.018	<0.0001	NSW - Vic	<0.0001
	Vic	2.79	0.96	3			NSW - Tas	<0.0001
	Tas	2.48	0.97	2	Vic - Tas	0.084		
	Club member	2.37	0.97	2	W = 7,291.5	0.987		
	Not member	2.38	1.00	2				

not significant ($H = 4.93$, $p = 0.08$; Table 3). There were, however, significant differences among states in terms of the attitudes towards catch-and-release, which yielded significant

differences in the number and percentage of makos released (Table 3). Based on statements about harvest and release preferences, an angler's stated release philosophy was a significant

predictor in the proportion of the shark catch being released ($\rho = -0.58$, $p < 0.0001$); therefore, 'revealed' and stated behaviour were congruent in this study. On average, fishing club members reported to have caught significantly more makos than non-members (club 4 ± 5 (SD), non-club 2 ± 3 ; $W = 6,446$; $p < 0.01$) but with no difference in the percentage of sharks released between these two groups (club: $67 \pm 35\%$, non-club: $62 \pm 41\%$; $W = 4,897$, $p = 0.80$). Regionally, however, NSW anglers ($82 \pm 31\%$) released a significantly higher proportion of their catch than anglers from both Vic ($51 \pm 39\%$; pairwise comparison $p < 0.01$) and Tas ($59 \pm 38\%$; pairwise comparison $p < 0.01$).

3.2.3 | Specialization

Respondents reported fishing a total of 2,143 angler-days for mako in the previous 12 months (individual mean: 7.5 ± 9.3 days), with no apparent relationship between the number of days spent fishing for mako and the percentage of sharks released ($F = 2.392$, $p = 0.12$). Factor analysis indicated that each component of the specialization index described too much of the variation to be collapsed into the sub-dimensions of experience, avidity, skill and centrality to lifestyle. As such, each variable is examined individually (Table 4).

Relative to non-members, fishing club members typically reported more years of fishing experience, fishing more days in a year specifically for mako (avidity), being more skilled, holding more fishing magazine subscriptions (centrality to lifestyle) and assigning slightly more importance to mako fishing amongst other types of fishing (Table 4). NSW anglers typically held more magazine subscriptions than Tas anglers; this was the only component of specialization to vary among states of residence (Table 4).

3.2.4 | Consumptive orientation

Components of consumptive orientation were suitable to be incorporated into their constituent scales evaluating the importance of harvest, catching a trophy fish/mako, catching numbers of fish/mako and catching something. This was true for both general fishing activity and mako-specific scales (Table 5). No significant differences were observed in any of the consumptive orientation dimensions between club membership and state of residence (Figure 2). In both general and specific scales, the pursuit of a trophy fish/mako shark was the factor with the highest agreement among anglers, followed by catching numbers of fish/mako sharks. Retaining the catch was the item with the lowest agreement for both scales. The mako-specific scale prompted significantly less consumptive responses for three of the four domains when compared to the general fishing activities scale (Table 5). Specifically, when anglers were targeting mako sharks, there was less agreement with the importance of retaining sharks, catching trophy sharks and catching more sharks compared to general fishing activities (Table 6).

4 | DISCUSSION

This study revealed a geographic difference in motivations and catch-and-release behaviour of shortfin mako anglers coinciding with regional variation (at the level of the 'state' in Australia) in the value that anglers attributed to the species as a sport and table fish. Fishing club membership was indicative of angler specialization; however, specialization was not indicative of catch-and-release behaviour. These results reveal a disconnect among fishing club membership, specialization and catch-and-release behaviour, and show that geography (and likely corresponding cultural norms) influenced catch-and-release behaviour. Behaviour can be a product of attitude or ethos developed through experience; for example, Røskaft, Händel, Bjerke, and Kaltenborn (2007) observed generally negative perception of native carnivores among hunters in Norway; such information is important to comprehend user groups and develop acceptable and effective management. Although much research has been conducted to investigate attitudes towards terrestrial predators (Conforti & de Azevedo, 2003; Lescureux & Linnell, 2010; Romanach, Lindsey, & Woodroffe, 2007; Røskaft et al., 2007; Suryawanshi, Bhatnagar, Redpath, & Mishra, 2013), less research has focused on people's perceptions of sharks. One study observed that sharks seem to be perceived as food fish; only 32% of American saltwater anglers disagreed that sharks are good to eat (McClellan Press et al., 2016). Nevertheless, most respondents in McClellan Press et al. (2016) agreed that sharks are positive for ecosystems and they commonly released sharks. This is at odds with our results; although we observed high release rates, we found anglers motivated to harvest sharks were more likely to harvest them. In relation to motivations for releasing sharks, the most agreement across groups was associated with an interest in conservation fishing and enjoyment in the sport of catch-and-release. The differences in motivations between club members and non-members were predominantly linked to the statements that related to fishing competitions, which is unsurprising given that only registered club members may participate in most tournaments in Australia. Club members were more likely to release mako sharks when trying to win tag-based competitions and more likely to keep mako sharks when fishing for trophies and trying to win weight-based competitions than were non-members. This indicates that, at least for fishing club members, behaviours may be modified by incentives provided during fishing competitions; however, as only club members may participate in these competitions, a large section of the angler population will remain unaffected by efforts to modify behaviours through these methods.

Our observation that release behaviour of anglers is influenced by their perceptions and motivations emphasizes the importance of educating participants. Understanding and appreciation of the ecological roles played by sharks and the threats confronted by them in a global context may be critical to programmes aiming to increase participation in catch-and-release (McClellan Press et al., 2016). However, this could still be challenging as Waylen, McGowan, Pawi

TABLE 4 Specialization of Australian shortfin mako shark anglers. Measures of experience, avidity, self-reported skill, and centrality of fishing and mako shark fishing to the lifestyle. Self-perceived skill level: anglers rated themselves either less (0), equally (1) or more (2) skilled than other game fishers when targeting mako sharks. b = Compared to other types of fishing, respondents rated mako fishing as either: the only type of fishing they do (1), the most important kind of fishing they do (2), the second most important type of fishing they do (3) or one of many types of fishing (4). c = Compared to other outdoor activities, respondents rated fishing as either: the only outdoor activity they participate in (1), their most important outdoor activity (2), second most important outdoor activity (3) or one of many activities they participate in (4)

Specialization parameter	State/Club member	Mean	SD	Median	Kruskal-Wallis/ Mann-Whitney statistics	p	Pairwise comparisons	p
Years of fishing experience	NSW	23.34	11.64	20	H = 0.9557	0.620		
	Vic	21.81	11.63	20				
	Tas	22.12	11.81	20				
	Club member	25.16	12.18	25	W = 6,888.5	0.002		
	Not member	20.75	11.16	20				
During the last 12 months, how many days have you fished salt water, whether you caught anything or not?	NSW	58.71	49.59	50	H = 2.429	0.297		
	Vic	51.30	47.88	38				
	Tas	55.04	43.16	45.5				
	Club member	55.93	41.72	42	W = 8,199	0.319		
	Not member	54.70	49.01	40				
During the last 12 months, how many days did you spend fishing for mako sharks, whether you caught any or not?	NSW	7.63	13.13	3	H = 4.427	0.109		
	Vic	7.15	6.43	5				
	Tas	6.96	5.80	5				
	Club member	9.08	11.92	6	W = 7,108.5	0.006		
	Not member	6.05	5.65	4				
Self-perceived skill level	NSW	0.76	0.78	1	H = 2.4891	0.288		
	Vic	0.93	0.76	1				
	Tas	0.88	0.72	1				
	Club member	1.19	0.74	1	W = 5,377.5	<0.0001		
	Not member	0.64	0.67	1				
Importance of mako fishing relative to other types of fishing	NSW	3.96	0.25	4	H = 3.404	0.182		
	Vic	3.86	0.45	4				
	Tas	3.90	0.42	4				
	Club member	3.85	0.51	4	W = 9,337.5	0.049		
	Not member	3.95	0.27	4				
Importance of fishing relative to other outdoor activities	NSW	2.40	0.87	2	H = 3.4675	0.177		
	Vic	2.20	0.88	2				
	Tas	2.41	0.91	2				
	Club member	2.32	0.89	2	W = 9,081.5	0.636		
	Not member	2.36	0.88	2				
How many subscriptions do you currently have to fishing related magazines?	NSW	0.76	0.82	1	H = 6.3665	0.041	NSW - Vic	1.000
	Vic	0.81	1.15	0				
	Tas	0.72	1.67	0	W = 7,428	0.014	NSW - Tas	0.042
	Club member	0.88	1.09	1			Vic - Tas	0.377
	Not member	0.68	1.43	0				

Study Group, and Milner-Gulland (2009) observed that conservation awareness is not necessarily sufficient to change behaviours; they reported that Trinidadians recognized hunting as a threat to species

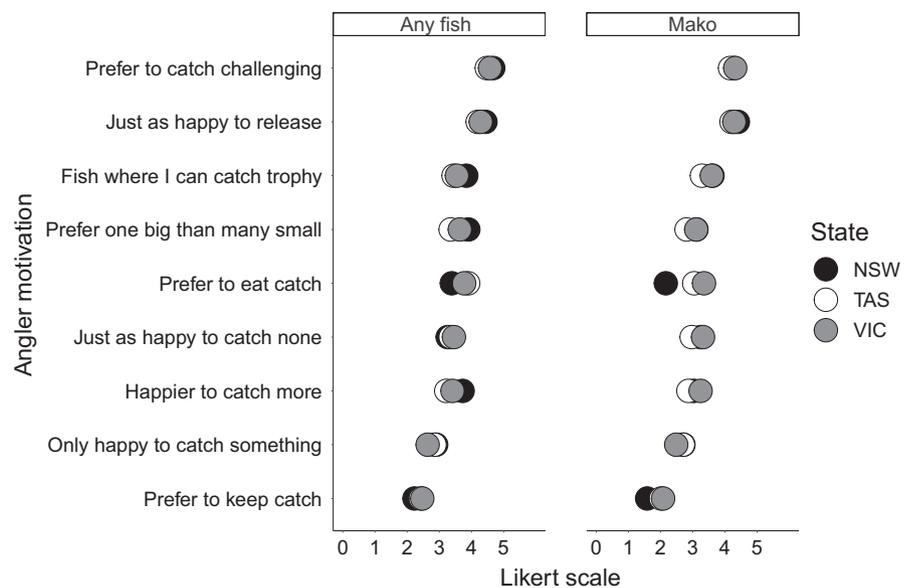
at risk and simultaneously engaged in hunting as a popular pastime. This debate over the compatibility of conservation and exploitation is complex (Cooke et al., 2016; Lindsey et al., 2007; Shiffman et al.,

TABLE 5 Factor analysis for satisfactions gained from general fishing for mako sharks *Isurus oxyrinchus*. Responses are strongly disagree (1), disagree (2), neutral (3), agree (4) and strongly agree (5). CFA fit indices: $n = 260$, $\chi^2 = 14.959$, $p < 0.864$, $df = 22$, CFI = 1.000, RMSEA = 0.000, SRMR = 0.039). Chronbach's alpha (α) is used as a measure of consistency among responses

Mako fishing	Mean	SD	Standardized factor loading	z-value
Keeping Mako ($\alpha = 0.76$)	2.16	0.87		
I usually eat the mako sharks I catch	2.88	1.34	0.540	8.490
I'm just as happy if I release the mako sharks I catch ^a	1.69	0.85	0.665	8.368
Within legal limits, I prefer to keep all the makos I catch	1.91	1.00	0.965	9.140
Catching a Trophy Mako ($\alpha = 0.66$)	3.53	0.83		
I would rather catch one big mako than several small makos	2.97	1.23	0.542	9.269
I'm happiest when I catch a challenging mako shark	4.18	0.83	0.494	8.144
I like to fish where I know I am most likely to catch a trophy-sized mako	3.43	1.13	0.884	10.169
Catching numbers of Mako ($\alpha = N/A$)	2.96	1.11		
The more mako sharks I catch the happier I am	2.96	1.11	1.000	27.905
Catching a Mako ($\alpha = 0.67$)	2.71	0.98		
I'm just as happy if I don't catch a mako ^a	2.81	1.12	0.612	9.401
I'm not satisfied with a mako fishing trip unless I catch at least one mako	2.61	1.15	0.830	9.401

^aReverse coded so that higher numbers represent higher consumptive orientation.

FIGURE 2 Consumptive orientation of Australian shortfin mako shark anglers in relation to recreational fishing in general (Any Fish) and specific to shortfin mako fishing (Mako). Mean motivation based on state of residence, where codes range from 1 (strongly disagree) to 5 (strongly agree), with 3 representing 'neutral'



2014) but ultimately a balance must be achieved and understanding that there are regional differences in the motivation to harvest mako sharks will assist in conservation programming. In similar studies of angler attitudes, significant heterogeneity in attitudes have also been reported, emphasizing the need for more nuanced approaches

to angler engagement and education that are informed by data describing local attitudes that can yield targeted messaging (Nguyen, Rudd, Cooke, & Hinch, 2012).

Fishing for mako sharks requires large watercraft, specialized equipment and shark handling experience, rendering it a specialized

Comparison of scales	W	p
Keeping fish/keeping mako	17,339.5	<0.0001
Catching a trophy fish/catching a trophy mako	14,929.5	<0.0001
Catching numbers of fish/catching numbers of mako	8,182	<0.0001
Catching something/catching a mako	7,787.5	0.788

TABLE 6 Comparison of factor values for general and specifically worded consumptive orientation scales. W = paired Wilcoxon test statistic

sport fishery (Henry & Lyle, 2003; Lyle, Stark, & Tracey, 2014; West, Stark, Murphy, Lyle, & Ochwada-Doyle, 2015). Indeed, respondents were experienced and displayed the characteristics of a highly specialized group (Ditton et al., 1992; Salz et al., 2001). Although we measured specialization among anglers, especially club members, it was unrelated to release behaviour of participants. Previous studies have described specialized anglers as being preceptive to resource disturbance, highly invested in the resource, committed to preserving the resource and more likely to practice catch-and-release (Gigliotti & Peyton, 1993; Fisher, 1997; Salz et al., 2001; Schuhmann & Schwabe, 2004; Sutton, 2001; Oh & Ditton, 2006). Sutton and Ditton (2001) suggested that experience may only be important to a point where it allows fishing to become a central part of the angler's lifestyle and hence, encourage them to engage in more resource conservative behaviours. Most likely, anglers in this study were all highly specialized to varying degrees, complicating comparisons.

Instead of differences among specializations, we observed regional differences in motivations to release sharks. Vic and Tas anglers expressed significantly more disagreement with releasing mako sharks because they were more likely to enjoy eating shark, and were significantly more likely to agree with retaining a shark because they were fishing for food than NSW anglers. These responses emphasize that shortfin mako's importance as a food item to these angler groups is a primary reason for its retention and highlights the culture of eating sharks in Vic and Tas. Regionality has also been described in Europe, where Ferter et al. (2013) suggested that cultural norms and other factors can have substantial impact on angler perceptions of their catch as well as their behaviour. Our data provide little insight into the mechanisms driving the differences among states, but access to shark meat likely differs; commercial shark fisheries are concentrated near Vic and Tas, where the main markets for shark are based (Patterson, Noriega, Georgeson, Larcombe, & Curtotti, 2017); shark flesh (aka 'flake') may therefore be more accessible and acceptable in these southern states. In NSW, anglers have a broader diversity of recognized gamefish species to target (Zischke, Griffiths, & Tibbetts, 2012) yielding greater substitutability of mako for other gamefish and potentially decreasing emphasis on harvesting mako sharks (Shelby & Vaske, 1991; Fisher & Ditton, 1993; Sutton & Ditton, 2005; Rogers & Bailleul, 2015).

Factors relating to the importance of keeping fish/makos, catching numbers of fish/makos, catching a trophy fish/mako and catching something/a mako were consistent with a number of previous studies (Aas & Vittersø, 2000; Anderson et al., 2007; Kyle

et al., 2007). For both general fishing and mako-specific fishing, catching a trophy was the most important contributor to angler satisfaction in this study and keeping fish was least important. Although there was variation in the harvest behaviour of anglers, most anglers did report a tendency to voluntarily release at least some shortfin mako shark. Responses indicated that most anglers tend to harvest some of the fish they catch but this was not true when focused specifically on catches of shortfin mako. Increasing desire to consume local food may yield changes in demand for local products including shark, and thereby participation in hunting and fishing (Cooke et al., 2018; Tidball, Tidball, & Curtis, 2013). Research is evidently needed to understand how willing consumers are to trade off sustainability and conservation when harvesting species at risk.

Surveys in which respondents are self-selected offer little control over the relative representation of groups and we appreciate the limitations of a survey that is administered on-line. Previous game-fishing surveys conducted with Tasmanian anglers revealed substantially lower release rates for mako shark (29%: Frijlink, 2011; 39%: Tracey et al., 2013) than we identified (59% for Tas or 73% overall). It is unclear whether these differences are due to sampling bias or a temporal trend towards increased adoption of catch-and-release fishing. Representation can influence results and it is possible that specialized anglers or anglers who already had a passion for shark conservation would be more likely to take the time to fill out this survey and as such, these results should be interpreted in the context of this potential bias. In addition, casual mako anglers are less likely to have been reached by this survey than avid anglers. These data are, therefore, most useful for identifying subgroups and varying attitudes and behaviours among these subgroups but they are unlikely to be representative of the game fishing community in its entirety.

4.1 | Management

Managing fisheries, particularly those for species at risk, is challenging because of the many incentives that anglers have to target fish, including for consumption. Satisfying multiple stakeholders in the ocean requires trade-offs, and ideally decisions should be made based on the available evidence. In most of the Australian states where mako shark are targeted, the daily bag limit has been set at one per person, but because vessels are typically crewed by two or more persons, the legally retained catch can be higher. Boat limits represent an option to reduce harvest and effectively promote release, especially when limits are low. Boats limits for mako

shark currently apply only in Tas (limit of two per trip). Instituting size limits is also a common practice that can encourage regulatory catch-and-release in fisheries (Lennox, Falkegård, Vøllestad, Cooke, & Thorstad, 2016); however, size limits for mako shark do not currently apply in any Australian states.

In promoting catch-and-release fishing or at least achieving acceptance of catch limits, anglers need to believe that most fish released voluntarily or due to regulation will survive. This is true for shortfin mako sharks, for which post release survival rates in recreational fisheries have been observed to be high (French et al., 2015). Given that they survive, managers may desire increased practice of catch-and-release, which could potentially be achieved in Vic and Tas by the provision of more desirable incentives to release sharks during fishing competitions, for example by eliminating weigh-ins that require bringing fish aboard or to a central processing location (Shiffman et al., 2014). Overall, the results of our study align with the general behaviour of shark anglers, who report practicing catch-and-release predominantly (McClellan Press et al., 2016). This is positive given that the most common motivations for mako fishing were reported to be the challenges and thrills rather than securing shark meat, a factor that is essential for effective messaging to anglers that value the species for recreation. Furthermore, although not reflected in this data set, mako anglers reported using gear types conducive to their motivations, with catch-and-release anglers more likely to use circle hooks, a measure that could be instituted as a conservation measure via management restrictions on gear use (Graves & Horodysky, 2008).

4.2 | Conclusions

Humans have a strained relationship with predators and understanding attitudes and behaviours towards these ecologically important species is critical (Dickman, 2010). Few studies have focused on understanding the perception of marine predators, particularly those that are economically important such as mako sharks. This study contributes to addressing the human dimension research priorities identified in a recent review of the status of science regarding shark recreational fisheries (Gallagher et al., 2017). Participants in hunting and fishing can exert significant influence over the management and sustainability of the resource when they make decisions about harvesting of animals. Harvest behaviour was primarily related to differences in the value afforded to shortfin mako as a sport or table fish among these regions such that actions closely related values. Human dimensions studies, such as we conducted here, assist in our capacity to manage fisheries for charismatic species such as sharks. Education programmes that emphasize the ecological value of mako sharks and the threats facing them as a vulnerable species are also needed to shift attitudes and values of anglers that reported valuing the species as a recreational target. Indeed, our data suggest that changes to motivations should yield congruent changes in behaviour. Inquiring about the motivations and behaviours of humans is essential information to management decisions. As conservation conflicts pervade, evidence-based decision-making becomes increasingly crucial to management. Appreciating how changing attitudes can

contribute to conflict resolution is therefore essential to develop a way forward for conservation, particularly of ecologically and economically important species.

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AUTHOR CONTRIBUTIONS

RPF, JML and JS conceived the study. RPF collected data. RPF and JML analysed data. RPF, JML, RJL, SJC and JS wrote the manuscript.

DATA ACCESSIBILITY

Data for this paper have been uploaded to be freely available to all interested parties and are accessible at <https://doi.org/10.5281/zenodo.2238376> (French, Lyle, Lennox, Cooke & Semmens, 2019).

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REFERENCES

- Aas, Ø., & Vittersø, J. (2000). Re-examining the consumptive-ness concept: Some suggestions from a confirmatory factor analysis. *Human Dimensions of Wildlife*, 5, 1–18. <https://doi.org/10.1080/10871200009359191>
- Anderson, D. K., Ditton, R. B., & Hunt, K. M. (2007). Measuring angler attitudes toward catch-related aspects of fishing. *Human Dimensions of Wildlife*, 12, 181–191. <https://doi.org/10.1080/10871200701323066>
- Arlinghaus, R., Cooke, S. J., Coleman, F. C., Figueira, W. F., Ueland, J. S., & Crowder, L. B. (2005). Global impact of recreational fisheries. *Science*, 307, 1561–1563. <https://doi.org/10.1126/science.307.5715.1561>
- Arlinghaus, R., Cooke, S. J., Lyman, J., Policansky, D., Schwab, A., Suski, C., ... Thorstad, E. B. (2007). Understanding the complexity of catch-and-release in recreational fishing: An integrative synthesis of global knowledge from historical, ethical, social, and biological perspectives. *Reviews in Fisheries Science*, 15, 75–167. <https://doi.org/10.1080/10641260601149432>
- Bruce, B. (2014). Shark futures: A synthesis of available data on mako and porbeagle sharks in Australasian waters. Current status and future directions. Fisheries Research and Development Corporation (FRDC). CSIRO, Hobart. pp. 159.
- Cailliet, G. M., Cavanagh, R. D., Kulka, D. W., Stevens, J. D., Soldo, A., Clo, S., ... Domingo A. (2009) *Isurus oxyrinchus*. The IUCN Red

- List of Threatened Species 2009: e.T39341A10207466. <https://doi.org/10.2305/IUCN.UK.2009-2.RLTS.T39341A10207466.en>. Downloaded on 16 November 2018.
- Coleman, F. C., Figueira, W. F., Ueland, J. S., & Crowder, L. B. (2004). The impact of United States recreational fisheries on marine fish populations. *Science*, 305, 1958–1960. <https://doi.org/10.1126/science.1100397>
- Conforti, V. A., & de Azevedo, F. C. C. (2003). Local perceptions of jaguars (*Panthera onca*) and pumas (*Puma concolor*) in the Iguazu National Park area, south Brazil. *Biological Conservation*, 111(2), 215–221.
- Cooke, S. J., & Cowx, I. G. (2004). The role of recreational fishing in global fish crises. *BioScience*, 54, 857–859. [https://doi.org/10.1641/0006-3568\(2004\)054\[0857:TRORFI\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2004)054[0857:TRORFI]2.0.CO;2)
- Cooke, S. J., Hogan, Z. S., Butcher, P. A., Stokesbury, M. J., Raghavan, R., Gallagher, A. J., & Danylchuk, A. J. (2016). Angling for endangered fish: Conservation problem or conservation action? *Fish and Fisheries*, 17, 249–265.
- Cooke, S. J., Twardek, W. M., Lennox, R. J., Zolderdo, A. J., Bower, S. D., Gutowsky, L. F., ... Beard, D. (2018). The nexus of fun and nutrition: Recreational fishing is also about food. *Fish and Fisheries*, 19(2), 201–224. <https://doi.org/10.1111/faf.12246>
- DEWHA (2010) Legislative changes for the recreational fishery of three shark species. Department of the Environment, Water, Heritage and the Arts, Canberra. http://www.environment.gov.au/system/files/resources/f59e0a2f-5998-44bd-90c5-3ea63b504a44/files/fs-three-sharks_0.pdf accessed 18 October 2018.
- Dickman, A. J. (2010). Complexities of conflict: The importance of considering social factors for effectively resolving human–wildlife conflict. *Animal Conservation*, 13(5), 458–466. <https://doi.org/10.1111/j.1469-1795.2010.00368.x>
- Ditton, R. B., Loomis, D. K., & Choi, S. (1992). Recreation specialization: Re-conceptualization from a social world's perspective. *Journal of Leisure Research*, 24, 33–51. <https://doi.org/10.1080/00222216.1992.11969870>
- Duba, D., & Nobile, J. L. (2010). The Fallacy of online surveys: No data are better than bad data. *Human Dimensions of Wildlife*, 15, 55–64. <https://doi.org/10.1080/10871200903244250>
- Dunn, O. J. (1964). Multiple comparisons using rank sums. *Technometrics*, 6, 241–252. <https://doi.org/10.1080/00401706.1964.10490181>
- Ellenberg, U., Setiawan, A. N., Cree, A., Houston, D. M., & Seddon, P. J. (2007). Elevated hormonal stress response and reduced reproductive output in yellow-eyed penguins exposed to unregulated tourism. *General and Comparative Endocrinology*, 152(1), 54–63. <https://doi.org/10.1016/j.ygcen.2007.02.022>
- Estes, J. A., Terborgh, J., Brashares, J. S., Power, M. E., Berger, J., Bond, W. J., ... Wardle, D. A. (2011). Trophic downgrading of planet Earth. *Science*, 333, 301–306. <https://doi.org/10.1126/science.1205106>
- Fedler, A., & Ditton, R. (1986). A framework for understanding the consumptive orientation of recreational fishermen. *Environmental Management*, 10, 221–227. <https://doi.org/10.1007/BF01867360>
- Ferter, K., Weltersbach, M. S., Strehlow, H. V., Vølstad, J. H., Alós, J., Arlinghaus, R., ... Veiga, P. (2013). Unexpectedly high catch-and-release rates in European marine recreational fisheries: Implications for science and management. *ICES Journal of Marine Science*, 70(7), 1319–1329. <https://doi.org/10.1093/icesjms/fst104>
- Fisher, M. R. (1997). Segmentation of the angler population by catch preference, participation, and experience: A management-oriented application of recreation specialization. *North American Journal of Fisheries Management*, 17, 1–10. [https://doi.org/10.1577/1548-8675\(1997\)017<0001:SOTAPB>2.3.CO;2](https://doi.org/10.1577/1548-8675(1997)017<0001:SOTAPB>2.3.CO;2)
- Fisher, M. R., & Ditton, R. B. (1993). A social and economic characterization of the US Gulf of Mexico recreational shark fishery. *Marine Fisheries Review*, 55, 21–27.
- Flora, D. B., & Curran, P. J. (2004). An empirical evaluation of alternative methods of estimation for confirmatory factor analysis with ordinal data. *Psychological Methods*, 9, 466–491. <https://doi.org/10.1037/1082-989X.9.4.466>
- French, R. P., Lyle, J. M., Lennox, R. J., Cooke, S. J., & Semmens, J. M. (2019). Data from: Motivation and harvesting behaviour of fishers in a specialized fishery targeting a top predator species at risk. *zenodo*. <https://doi.org/10.5281/zenodo.2238376>.
- French, R. P., Lyle, J., Tracey, S., Currie, S., & Semmens, J. M. (2015). High survivorship after catch-and-release fishing suggests physiological resilience in the endothermic shortfin mako shark (*Isurus oxyrinchus*). *Conservation Physiology*, 3, <https://doi.org/10.1093/conphys/cov044>
- Friedrich, L. A., Jefferson, R., & Glegg, G. (2014). Public perceptions of sharks: Gathering support for shark conservation. *Marine Policy*, 47, 1–7. <https://doi.org/10.1016/j.marpol.2014.02.003>
- Frijlink, S. (2011). A Socioeconomic Assessment of the Tasmanian Game Fishery. PhD. Doctoral Thesis, University of Tasmania, Hobart.
- Galeano, D., Langenkamp, D., Levantis, C., Shafron, W., & Redmond, I. (2004). Economic value of charter and recreational fishing in Australia's eastern tuna and billfish fishery. ABARE eReport. Australian Government, Canberra, Australia, pp. 42.
- Gallagher, A. J., Cooke, S. J., & Hammerschlag, N. (2015). Risk perceptions and conservation ethic among recreational anglers targeting threatened sharks in the subtropical Atlantic. *Endangered Species Research*, 29, 81–93. <https://doi.org/10.3354/esr00704>
- Gallagher, A. J., Hammerschlag, N., Danylchuk, A. J., & Cooke, S. J. (2017). Shark recreational fisheries: Status, challenges, and research needs. *Ambio*, 46, 385–398. <https://doi.org/10.1007/s13280-016-0856-8>
- Giglio, V. J., Luiz, O. J., & Schiavetti, A. (2015). Marine life preferences and perceptions among recreational divers in Brazilian coral reefs. *Tourism Management*, 51, 49–57. <https://doi.org/10.1016/j.tourman.2015.04.006>
- Gigliotti, L. M., & Peyton, R. B. (1993). Values and behaviors of trout anglers, and their attitudes toward fishery management, relative to membership in fishing organizations: A Michigan case study. *North American Journal of Fisheries Management*, 13, 492–501. [https://doi.org/10.1577/1548-8675\(1993\)013<0492:VABOTA>2.3.CO;2](https://doi.org/10.1577/1548-8675(1993)013<0492:VABOTA>2.3.CO;2)
- Graefe, A. R. (1980). *The relationship between the level of participation and selected aspects of specialisation in recreational fishing*. Doctoral Thesis, Texas A&M University, USA.
- Graefe, A. R., & Ditton, R. B. (1997). Understanding catch and release behaviour among billfish anglers. *Proceedings of the Annual Gulf and Caribbean Fisheries Institute*, 49, 430–455.
- Grambsch, A. E., & Fisher, M. F. (1991). Catch and release statistics for U.S. bass and trout anglers, Creel and Angler Surveys in Fisheries. *Management - American Fisheries Society Symposium 12: American Fisheries Society*, 390–396.
- Graves, J. E., & Horodysky, A. Z. (2008). Does hook choice matter? Effects of three circle hook models on post release survival of white marlin. *North American Journal of Fisheries Management*, 28, 471–480. <https://doi.org/10.1577/M07-107.1>
- Griffin, L. P., Brownscombe, J. W., Gagné, T. O., Wilson, A. D., Cooke, S. J., & Danylchuk, A. J. (2017). Individual-level behavioral responses of immature green turtles to snorkeler disturbance. *Oecologia*, 183(3), 909–917. <https://doi.org/10.1007/s00442-016-3804-1>
- Hasler, C. T., Colotelo, A. H., Rapp, T., Jamieson, E., Bellehumeur, K., Arlinghaus, R., & Cooke, S. J. (2011). Opinions of fisheries researchers, managers, and anglers towards recreational fishing issues: an exploratory analysis for North America. In T. D. Beard, R. Arlinghaus, & S. G. Sutton (Eds.), *American Fisheries Society Symposium* (Vol. 75, No. PNNL-SA-76190). Richland, WA: Pacific Northwest National Lab.
- Heard, M., Sutton, S., Rogers, P., & Huvneers, C. (2016). Actions speak louder than words: Tournament angling as an avenue to promote best practice for pelagic shark fishing. *Marine Policy*, 64, 168–173. <https://doi.org/10.1016/j.marpol.2015.11.019>
- Henry, G. W., & Lyle, J. M. (2003). National recreational and indigenous fishing survey. FRDC Project No. 99/158. Department of Agriculture,

- Fisheries and Forestry, Australian Government, Canberra, Australia, pp 188.
- Hickley, P., & Tompkins, H. (1998). *Recreational Fisheries: Social, Economic, and Management Aspects*. Oxford: Fishing News Books.
- Hu, L.-T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, 6, 1–55. <https://doi.org/10.1080/10705519909540118>
- Jensen, O. P., Gilroy, D. J., Hogan, Z., Allen, B. C., Hrabik, T. R., Weidel, B. C., ... Vander Zanden, M. J. (2009). Evaluating recreational fisheries for an endangered species: A case study of taimen, *Hucho taimen*, in Mongolia. *Canadian Journal of Fisheries and Aquatic Sciences*, 66, 1707–1718. <https://doi.org/10.1139/F09-109>
- Kellert, S. R. (1985). Public perceptions of predators, particularly the wolf and coyote. *Biological Conservation*, 31, 167–189. [https://doi.org/10.1016/0006-3207\(85\)90047-3](https://doi.org/10.1016/0006-3207(85)90047-3)
- Kellert, S. R., Black, M., Rush, C. R., & Bath, A. J. (1996). Human culture and large carnivore conservation in North America. *Conservation Biology*, 10(4), 977–990. <https://doi.org/10.1046/j.1523-1739.1996.10040977.x>
- Korkmaz, S., Goksuluk, D., & Zararsiz, G. (2014). MVN: An R package for assessing multivariate normality. *The R Journal*, 6, 151–162.
- Kyle, G., Norman, W., Jodice, L., Graefe, A., & Marsinko, A. (2007). Segmenting anglers using their consumptive orientation profiles. *Human Dimensions of Wildlife*, 12, 115–132. <https://doi.org/10.1080/10871200701196066>
- Lennox, R. J., Falkegård, M., Vøllestad, L. A., Cooke, S. J., & Thorstad, E. B. (2016). Influence of harvest restrictions on angler release behaviour and size selection in a recreational fishery. *Journal of Environmental Management*, 176, 139–148. <https://doi.org/10.1016/j.jenvman.2016.03.031>
- Lennox, R. J., Gallagher, A. J., Ritchie, E. G., & Cooke, S. J. (2018). Evaluating the efficacy of predator removal in a conflict-prone world. *Biological Conservation*, 224, 277–289. <https://doi.org/10.1016/j.biocon.2018.05.003>
- Lescureux, N., & Linnell, J. D. (2010). Knowledge and perceptions of Macedonian hunters and herders: The influence of species specific ecology of bears, wolves, and lynx. *Human Ecology*, 38(3), 389–399. <https://doi.org/10.1007/s10745-010-9326-2>
- Lewin, W.-C., Arlinghaus, R., & Mehner, T. (2006). Documented and potential biological impacts of recreational fishing: Insights for management and conservation. *Reviews in Fisheries Science*, 14, 305–367. <https://doi.org/10.1080/10641260600886455>
- Lindsey, P. A., Roulet, P. A., & Romanach, S. S. (2007). Economic and conservation significance of the trophy hunting industry in sub-Saharan Africa. *Biological Conservation*, 134(4), 455–469. <https://doi.org/10.1016/j.biocon.2006.09.005>
- Lyle, J. M., Stark, K. E., & Tracey, S. R. (2014). 2012/13 Survey of recreational fishing in Tasmania. Fishwise Community Grants Final Report. Institute for Marine and Antarctic Studies, Hobart, Tasmania.
- McClellan Press, K., Mandelman, J., Burgess, E., Cooke, S. J., Nguyen, V. M., & Danylchuk, A. J. (2016). Catching sharks: Recreational saltwater angler behaviours and attitudes regarding shark encounters and conservation. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 26, 689–702. <https://doi.org/10.1002/aqc.2581>
- McPhee, D. P., Leadbitter, D., & Skilleter, G. (2002). Swallowing the bait: Is recreational fishing in Australia ecologically sustainable. *Pacific Conservation Biology*, 8, 40–51. <https://doi.org/10.1071/PC020040>
- Mindrila, D. (2010). Maximum likelihood (ML) and diagonally weighted least squares (DWLS) estimation procedures: A comparison of estimation bias with ordinal and multivariate non-normal data. *International Journal of Digital Society*, 1(1), 60–66.
- Myers, R. A., & Worm, B. (2003). Rapid worldwide depletion of predatory fish communities. *Nature*, 423(6937), 280. <https://doi.org/10.1038/nature01610>
- Neff, C. L., & Yang, J. Y. (2013). Shark bites and public attitudes: Policy implications from the first before and after shark bite survey. *Marine Policy*, 38, 545–547. <https://doi.org/10.1016/j.marpol.2012.06.017>
- Newsome, T. M., Greenville, A. C., Čirović, D., Dickman, C. R., Johnson, C. N., Krofel, M., ... Wirsing, A. J. (2017). Top predators constrain mesopredator distributions. *Nature Communications*, 8, 15469.
- Nguyen, V. M., Rudd, M., Cooke, S. J., & Hinch, S. G. (2012). Differences in information use and preferences among recreational salmon anglers: Implications for management initiatives to promote responsible fishing. *Human Dimensions of Wildlife*, 17, 248–256. <https://doi.org/10.1080/10871209.2012.675412>
- Nielsen, L. A. (1999). History of inland fisheries management in North America. In C. C. Kohler, & W. A. Hubert (Eds.), *Inland fisheries management in North America* (2nd ed., pp. 3–30). Bethesda, Maryland, USA: American Fisheries Society.
- Oh, C.-O., & Ditton, R. B. (2006). Using recreation specialization to understand multi-attribute management preferences. *Leisure Sciences*, 28, 369–384. <https://doi.org/10.1080/01490400600745886>
- Patterson, H., Noriega, R., Georgeson, L., Larcombe, J., & Curtotti, R. (2017). *Fishery status reports 2017*. Canberra: Australian Bureau of Agricultural and Resource Economics and Sciences.
- Peterson, M. J., & Carothers, C. (2013). Whale interactions with Alaskan sablefish and Pacific halibut fisheries: Surveying fishermen perception, changing fishing practices and mitigation. *Marine Policy*, 42, 315–324. <https://doi.org/10.1016/j.marpol.2013.04.001>
- Philpott, R. (2002). Why sharks may have nothing to fear more than fear itself: An analysis of the effect of human attitudes on the conservation of the great white shark. *Colorado Journal of International Environmental Law and Policy*, 13, 445–472.
- Pohlert, T. (2014). *The pairwise multiple comparison of mean ranks package (PMCMR)*, R package. <https://cran.r-project.org/web/packages/PMCMR/vignettes/PMCMR.pdf>
- Post, J. R., Sullivan, M., Cox, S., Lester, N. P., Walters, C. J., Parkinson, E. A., ... Shuter, B. J. (2002). Canada's recreational fisheries: The invisible collapse? *Fisheries*, 27, 6–17.
- Prayaga, P., Rolfe, J., & Stoeckl, N. (2010). The value of recreational fishing in the Great Barrier Reef, Australia: A pooled revealed preference and contingent behaviour model. *Marine Policy*, 34, 244–251. <https://doi.org/10.1016/j.marpol.2009.07.002>
- Purvis, A., Gittleman, J. L., Cowlshaw, G., & Mace, G. M. (2000). Predicting extinction risk in declining species. Proceedings of the Royal Society of London. *Series B: Biological Sciences*, 267 1947–1952. <https://doi.org/10.1098/rspb.2000.1234>
- R Core Team (2014). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. <http://www.R-project.org/>.
- Ripple, W. J., Estes, J. A., Beschta, R. L., Wilmers, C. C., Ritchie, E. G., Hebblewhite, M., ... WallachAD, W. A. J. (2014). Status and ecological effects of the world's largest carnivores. *Science*, 343(6167), 1241484. <https://doi.org/10.1126/science.1241484>
- Rogers, P., & Bailleul, F. (2015) Innovative ways to ensure the future sustainability of the recreational fishery for shortfin makos in Victoria. The State of Victoria, Department of Economic Development, Jobs, Transport & Resources Recreational Fishing Grants Program Research Report. South Australian Research and Development Institute (Aquatic Sciences). SARDI Publication No. F2015/000618-1, SARDI Research Report Series No. 872, Adelaide, Australia, pp 60.
- Romanach, S. S., Lindsey, P. A., & Woodroffe, R. (2007). Determinants of attitudes towards predators in central Kenya and suggestions for increasing tolerance in livestock dominated landscapes. *Oryx*, 41(2), 185–195. <https://doi.org/10.1017/S0030605307001779>
- Røskoft, E., Händel, B., Bjerke, T., & Kaltenborn, B. P. (2007). Human attitudes towards large carnivores in Norway. *Wildlife Biology*, 13(2), 172–185. [https://doi.org/10.2981/0909-6396\(2007\)13\[172:HATLCI\]2.0.CO;2](https://doi.org/10.2981/0909-6396(2007)13[172:HATLCI]2.0.CO;2)

- Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. *Journal of Statistical Software*, 48, 1–36.
- Salz, R. J., Loomis, D. K., & Finn, K. L. (2001). Development and validation of a specialization index and testing of specialization theory. *Human Dimensions of Wildlife*, 6, 239–258. <https://doi.org/10.1080/108712001753473939>
- Schreiber, J. B., Nora, A., Stage, F. K., Barlow, E. A., & King, J. (2006). Reporting structural equation modeling and confirmatory factor analysis results: A review. *The Journal of Educational Research*, 99, 323–338. <https://doi.org/10.3200/JOER.99.6.323-338>
- Schuhmann, P. W., & Schwabe, K. A. (2004). An analysis of congestion measures and heterogeneous angler preferences in a random utility model of recreational fishing. *Environmental and Resource Economics*, 27, 429–450. <https://doi.org/10.1023/B:EARE.0000018517.33432.0b>
- Sergio, F., Caro, T., Brown, D., Clucas, B., Hunter, J., Ketchum, J., ... Hiraldo, F. (2008). Top predators as conservation tools: Ecological rationale, assumptions, and efficacy. *Annual Review of Ecology, Evolution, and Systematics*, 39, 1–19. <https://doi.org/10.1146/annurev.ecolsys.39.110707.173545>
- Shelby, B., & Vaske, J. J. (1991). Resource and activity substitutes for recreational salmon fishing in New Zealand. *Leisure Sciences*, 13, 21–32. <https://doi.org/10.1080/01490409109513122>
- Shiffman, D. S., Gallagher, A., Wester, J., Macdonald, C. C., Thaler, A. D., Cooke, S. J., & Hammerschlag, N. (2014). Trophy fishing for species threatened with extinction: A way forward building on a history of conservation. *Marine Policy*, 50, 318–322. <https://doi.org/10.1016/j.marpol.2014.07.001>
- Shrestha, R. K., Seidl, A. F., & Moraes, A. Z. (2002). Value of recreational fishing in the Brazilian Pantanal: A travel cost analysis using count data models. *Ecological Economics*, 42, 289–299. [https://doi.org/10.1016/S0921-8009\(02\)00106-4](https://doi.org/10.1016/S0921-8009(02)00106-4)
- Stevens, J. D. (2008). The biology and ecology of the shortfin mako shark, *Isurus oxyrinchus*. In M. Camhi, E. Pikitch, & E. Babcock (Eds.), *Sharks of the Open Ocean: Biology* (pp. 87–94). Fisheries and Conservation, Oxford, UK: Blackwell Publishing.
- Suryawanshi, K. R., Bhatnagar, Y. V., Redpath, S., & Mishra, C. (2013). People, predators and perceptions: Patterns of livestock depredation by snow leopards and wolves. *Journal of Applied Ecology*, 50(3), 550–560. <https://doi.org/10.1111/1365-2664.12061>
- Sutton, S. G. (2001). *Understanding the catch and release behaviour of recreational anglers*. Doctoral Thesis, Texas A&M University, USA.
- Sutton, S. (2003). Personal and situational determinants of catch-and-release choice of freshwater anglers. *Human Dimensions of Wildlife*, 8, 109–126. <https://doi.org/10.1080/10871200304300>
- Sutton, S. G., & Ditton, R. B. (2001). Understanding catch-and-release behavior among U.S. Atlantic bluefin tuna anglers. *Human Dimensions of Wildlife*, 6, 49–66. <https://doi.org/10.1080/10871200152668698>
- Sutton, S. G., & Ditton, R. B. (2005). The substitutability of one type of fishing for another. *North American Journal of Fisheries Management*, 25, 536–546.
- Tidball, K. G., Tidball, M. M., & Curtis, P. (2013). Extending the locavore movement to wild fish and game: Questions and implications. *Natural Sciences Education*, 42(1), 185–189. <https://doi.org/10.4195/nse.2013.0024>
- Topelko, K. N., & Dearden, P. (2005). The shark watching industry and its potential contribution to shark conservation. *Journal of Ecotourism*, 4(2), 108–128. <https://doi.org/10.1080/14724040409480343>
- Tracey, S. R., Lyle, J. M., Ewing, G., Hartmann, K., & Mapleson, A. (2013). *Offshore recreational fishing in Tasmania 2011/12*. Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, 94p.
- Vaske, J. J., Jacobs, M. H., Sijtsma, M. T. J., & Beaman, J. (2011). Can weighting compensate for sampling issues in internet surveys? *Human Dimensions of Wildlife*, 16, 200–215.
- Wallmo, K., & Gentner, B. (2008). Catch-and-release fishing: A comparison of intended and actual behavior of marine anglers. *North American Journal of Fisheries Management*, 28, 1459–1471. <https://doi.org/10.1577/M07-062.1>
- Waylen, K. A., McGowan, P. J. K., Pawi Study Group, Milner-Gulland, E. J. (2009). Ecotourism positively affects awareness and attitudes but not conservation behaviours: A case study at Grande Riviere, Trinidad. *Onyx*, 43, 343–351. <https://doi.org/10.1017/S0030605309000064>
- Wells, R. M. G., & Davie, P. S. (1985). Oxygen binding by the blood and hematological effects of capture stress in two big gamefish: Mako shark and striped marlin. *Comparative Biochemistry and Physiology Part A: Physiology*, 81, 643–646. [https://doi.org/10.1016/0300-9629\(85\)91041-2](https://doi.org/10.1016/0300-9629(85)91041-2)
- West, L. D., Stark, K. E., Murphy, J. J., Lyle, J. M., & Ochwada-Doyle, F. A. (2015). Survey of recreational fishing in New South Wales and the ACT, 2013/14. Fisheries Final Report Series No. 149, NSW Department of Primary Industries, 150 p.
- Williams, R., Trites, A. W., & Bain, D. E. (2002). Behavioural responses of killer whales (*Orcinus orca*) to whale-watching boats: Opportunistic observations and experimental approaches. *Journal of Zoology*, 256(2), 255–270.
- Zischke, M. T., Griffiths, S. P., & Tibbetts, I. R. (2012). Catch and effort from a specialised recreational pelagic sport fishery off eastern Australia. *Fisheries Research*, 127, 61–72. <https://doi.org/10.1016/j.fishres.2012.04.011>

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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