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Predicting differences in angler beliefs, threat perceptions, and actions in British Columbia's rainbow trout and steelhead fisheries

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ABSTRACT

Anglers are a diverse population whose behaviours and perspectives are influenced by a myriad of factors including knowledge, expertise, management actions, and regulations. We examine similarities and differences in behaviours and perspectives amongst freshwater anglers of rainbow trout and steelhead (*Oncorhynchus mykiss*) in British Columbia, Canada, using an online survey. Findings from the survey suggest that subgroups or "types" of anglers are identifiable by differences in their behaviours and perspectives according to geographic area, gear type, fishery, and frequency of fishing activities. Our results indicate that angler types share many of the same motivations for engaging in fishing behaviours and similar concerns regarding threats to their preferred fishery; however, differences were evident across types of issues related to angler behaviour, as well as views on fisheries management. Overall, we argue that understanding fishery-scale angler heterogeneity can benefit fisheries management by highlighting areas of agreement and disagreement and encouraging tailored communications and relationship-building with important angler subgroups.

Introduction

Bryan (1977, 2000) described the concept of 'recreation specialization' in which individuals progress over time from general to more specific goals and interests in their chosen sport. In recreational fisheries, this process is often described in terms of angler expertise, such that as anglers become more experienced, they move through a continuum of motivations and orientations. For example, anglers may shift their interest over time from catching more fish to catching many different species to catching trophy fish (Ditton et al., 1992; Sutton and Ditton, 2001). The concept of recreation specialization has been linked to numerous other facets of recreation, including the choices people make related to experience preferences, consumptive orientation, and place attachment (Oh et al., 2012).

Angler choice and resulting behaviours can stem from external factors such as the state of fish stocks and management actions or regulations (e.g., Carruthers et al., 2019). These external factors linked with angler choices influence angler satisfaction, which is described as a combination of the result of behavioural choices, catch quality and other factors such as psychosocial benefits (Arlinghaus et al., 2007; Fenichel et al., 2013). Angler choices are also often influenced by internal factors, such as the angler's knowledge and perceptions. Information that can influence angler choice can include local knowledge, the targeted species, and any best practices associated with a species or system. Angler perceptions that can influence angler choices can include support for (or lack of support for) management and regulatory bodies, trust in regulatory and management bodies, and trust in information sources. The choices anglers make regarding their own fishing activities exert influence beyond the individual angler including on other anglers (e.g., behaviour; Hunt et al., 2013), the environment (e.g., changes to habitat; Post et al., 2008), and the fish they target (e.g., fish behaviour; Klefoth et al., 2008; or fish mortality, Bartholomew and Bohnsack, 2005). Therefore, understanding the choices anglers make about how, how much, where, and when to fish are crucial for supporting management of

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sustainable recreational fisheries (Johnston et al., 2010). It is important to understand the relationship between angler choices and behaviours that contribute to satisfaction; however, in circumstances where the relationship between angler satisfaction and fishery or habitat quality is not linear, for example, when the target species or aquatic ecosystem in question is threatened, angler choice metrics (and resulting wellbeing or satisfaction) could also potentially act as indicators of the need for management changes, such as improving relationships, restoration, or conservation.

The question of identifying different features of angler choice is of particular interest when considering differences in angler values, perspectives, and behaviour related to different fisheries for rainbow trout (*Oncorhynchus mykiss*) in British Columbia (BC), Canada (within the native range of rainbow trout). Rainbow trout exhibits two broad life-history types that include a lake and stream-resident form known as rainbow trout (i.e., entirely freshwater) and an anadromous form that migrates to the ocean known as steelhead trout. Further, rainbow trout have a vibrant pink stripe that runs laterally along their streamlined body, displaying a range of colours, while steelhead tend to be more silver. These two forms of rainbow trout provide different opportunities for angling in BC: resident rainbow trout can be angled with fly, bait, or lure fishing year-round in lakes and rivers, while the steelhead recreational fishery is more associated with fly fishing in streams and rivers on a seasonal basis owing to their migrations. Rainbow trout are widely dispersed throughout BC and were classified at S4 status by the BC government in 2012, meaning that while vulnerable to overfishing, populations are currently stable (BC Conservation Data Centre, 2011). BC has designated wild steelhead as a catch-and-release only fishery since 1997, and in 2018, the Thompson River and Chilcotin River populations were declared 'Endangered' by the Committee on the Status of Endangered Wildlife in Canada (Province of British Columbia, 2020). This overall duality, coupled with the steelhead's uncertain status and rainbow trout's more healthy status, provided a unique opportunity to examine angler choice from the perspective of preferred life history form (herein called "fishery"), where one form could be viewed as being low conservation risk and the other could be viewed as being high conservation risk.

Both rainbow trout and steelhead fisheries are important to BC anglers and to the BC economy. In 2010, there were an estimated 247,582 active resident anglers in BC fresh waters, which is approximately 5.2 % of the BC population (Fisheries and Oceans Canada, 2019). This activity accounts for an estimated 2.5 million angler days (Fisheries and Oceans Canada, 2010) and generates on average $800 million USD per year in revenue (Bailey and Sumaila, 2012). Rainbow trout were described as the favourite fish (to angle) by 50.1 % of BC freshwater anglers, and a near-favourite (second to fourth favourite) by an additional 32.9 % of BC freshwater anglers (Bailey and Sumaila, 2012). Unfortunately, there are no data available to clearly detail the exact population of rainbow trout anglers in BC, but using the information available we can broadly estimate that there are approximately ~205,000 resident BC anglers who would potentially self-identify as a rainbow trout angler (83 % of 247, 582 freshwater anglers). Steelhead anglers require a stamp to fish for steelhead each year, and approximately 14,000 anglers purchase stamps each year (Adrian Clarke, Freshwater Fisheries Society of BC, personal communication), though it is not known how many anglers use them.

Our primary goal in this study was to analyse descriptive survey data to provide a snapshot of angler perspectives on *O. mykiss* recreational fisheries in BC. We were also interested in exploring whether different behavioural outcomes of angler choice vary according to angler type as well as by angler perspectives on a range of issues in BC's recreational fisheries. Our aim is to explore areas of overlap and divergence in angler behaviours to better inform management. Our data for this analysis come from a recreational fisheries survey targeting BC rainbow trout and steelhead anglers conducted in 2018. The survey includes data on angler behaviours such as preferred gear types, preferred location types, frequency of engaging in angling behaviour, and preferred fishery. Using these data, we constructed angler profiles or "types" to compare against perspectives on conservation and fisheries management.

Methods

Survey design and distribution

Although a random sample survey would be ideal, this was not feasible due to inaccessibility of a complete population frame. Therefore, we used a broadcast method for survey distribution (e.g., Ayachi et al., 2015). As a result, no inferential statistics are provided, and no inferences beyond the sample population are made. The survey consisted of 36 closed- and open-ended questions designed to identify angler demographics and perspectives on a range of issues including behaviour, threat perception, management activities, and motivation. The survey included ten Likert-style questions, 18 multiple-choice questions, and one open-ended question. Additionally, 12 opportunities were built into the survey for respondents to provide context to their answers. Specifically, 11 of the multiple-choice questions included areas to elaborate or specify the reason for choices, and one Likert type question included eight categories and eight opportunities to elaborate or specify the reason for choices. The survey was built and operated using the online Qualtrics software and was approved by the Carleton University Research Ethics Board, #10,733.

As described in Jeanson et al. (2021), the 36-question survey was pretested with key informants. The survey was piloted to three anglers with experience fishing for rainbow trout in BC prior to survey launch, and the pilot process indicated that completion time of approximately 15 minutes. Several minor refinements were made to address ambiguities prior to launching the survey. The survey was available from the beginning of April 2018 to mid-October 2018 (i.e., during angling season) and was distributed using social media platforms through personal researcher accounts (Twitter and Facebook) and paid targeted advertising (Facebook). Partnering organizations (The Freshwater Fisheries Society of BC and Angler's Atlas) also assisted with distribution by including the survey link in email newsletters. Full text of the survey is available in Supplementary Materials.

Survey analysis

We separated the survey questions into categories based on whether the questions examined beliefs, threat perceptions, or actions (see Table 1). For each category, results from closed-ended perspectives are presented first as an overall perspective (the 'snapshot'), followed by model results from quantitative analysis of differences in response by angler type, and close with the additional context supplied by open-ended question results. Due to the nature of the analysis, the number of models run prohibited providing details on each outcome. Thus, relevant results are reported here, with additional results made available in Supplementary Materials.

Closed-ended question analysis

There were 36 closed- and open-ended questions in this survey, offering respondents opportunities to choose amongst supplied Likert-type responses (e.g., ranging from 'always' to 'never' and multiple choice-type responses). When appropriate, additional options such as 'I don't know' were also supplied. Closed-ended questions were analysed first as a whole, providing descriptive statistics or counts for the entire respondent population, and then analysed according to angler types.

Assigning angler types

Angler types were determined by fishing frequency, activity, and location as described by respondents in answers to Question 11 and by preferred fishery (rainbow or steelhead) as determined by Question 12.

Table 1
Questions included in the online survey titled "Threats to rainbow trout and steelhead in British Columbia.".

Category	Question Number	Question	Sub-Question	Options
Beliefs	8	Please indicate your level of agreement or disagreement with the following statements:	I fish to relax, I fish to catch trophy fish (large and/or heavy), I fish to spend time with others, I fish to spend time outdoors, I fish for food, I share my fishing photos on social media, Fishing is an important activity for my group of friends, Fishing is my favourite leisure activity, Fishing is a big part of my life	Strongly agree, Agree, Neither, Strongly disagree, I don't know
	9	Do you find yourself unsatisfied with a fishing trip when you do not catch at least one fish?	N/A	Yes, No, I don't know
	10	Is your satisfaction with a fishing trip based on the number of fish you catch?	N/A	Yes, No, I don't know
	30	Are you able to differentiate a wild and a hatchery reared fish?	N/A	Yes, No, I don't know
	31	Do you treat wild and hatchery-raised fish differently?	N/A	Yes, No, I don't know, No, Only during catch-and-release fishing
	32	Do you minimize the air exposure of fish caught during catch and release fishing?	N/A	Yes, No, Rather not say
	33	Do you harvest fish that you would otherwise release when it is injured or sufficiently stressed that it is unable to swim away in good condition?	N/A	Yes always, Yes sometimes, No, I don't know
	36	Do you currently participate in activities promoting or demonstrating responsible angling or fish conservation in BC?	N/A	Yes, No, I don't know
Threat Perceptions	13	Please indicate your level of agreement or disagreement with the following statements:	I believe that fish populations in BC are currently at risk of decline due to environmental changes, I believe that fish populations in British Columbia are currently declining due to environmental changes	Strongly agree, Agree, Neither, Strongly disagree, I don't know
	14	In your opinion, how much of a threat do the following factors pose to fish populations?	Climate change, Recreational fishing, Commercial bycatch, Human made waterway barriers, First Nations fishing, Oil and gas drilling, Sea Lice, Water quality, Habitat alterations, Fish farming/Aquaculture, Fish disease, Invasive species, Poor management, Construction activities, Poaching, Predation, Forestry, Agriculture, Mining	Strongly agree, Agree, Neither, Strongly disagree, I don't know
	15	In your opinion, what is the biggest single threat to fish populations in BC	N/A	Open ended
	16	In your opinion, over the past ten years, water temperatures of the waters you regularly fish in BC	N/A	Have increased, Have stayed the same, Have decreased, Unsure
	17	In your opinion, over the next ten years, water temperatures of the waters you regularly fish in BC	N/A	Will increase, Will stay the same, Will decrease, Unsure
	18	In your opinion, climate change in BC is	N/A	A very serios problem, A somewhat serious problem, Not a problem
	19	Please indicate your level of agreement or disagreement with the following statements:	I believe that climate change will not harm fish populations in British Columbia for many years, I believe that climate change will never harm fish populations in BC	Strongly agree, Agree, Neither, Strongly disagree, I don't know
Actions	20	If scientific studies were to show that minimizing air exposure of fish caught at high water temperatures reduces the likelihood of mortality, would you change your fishing behaviour in any way?	N/A	Yes, No I already minimize air exposure during periods of high water temperature, No other reason, I don't know
	21	If scientific studies were to show that the frequency or duration of fishing trips should be reduced during periods of high water temperature, would you change your fishing behaviour in any way?	N/A	Yes, No I already avoid fishing during periods of high water temperature, No other reason, I don't know
	22	Please indicate your level of agreement or disagreement with the following statement	I would purchase fishing gear that has been scientifically tested to reduce harm to angled fish, I would take a free online course on the proper handling of angled fish	Very likely, Likely, Neither likely nor unlikely, Unlikely, Very unlikely, I don't know

(*continued on next page*)

Table 1 (*continued*)

Category	Question Number	Question	Sub-Question	Options
	23	Would you be willing to use a de-hooking device on your next fishing trip?	N/A	Yes voluntarily, Yes only if required, No, I already use
	24	In your opinion, how effective are the following measures at protecting fish populations?	Winter closures, Spring closures, Summer closures, Yearly catch limits, Daily catch limits, Gear restrictions, Annual harvest limits, Catch and Release (no harvest)	Very effective, Somewhat effective, Not effective, Not effective, I don't know, Not applicable
	25	Have you ever wanted to go fishing for fish but have been unable to due to a closure?	N/A	Yes, No, I would rather not say
	26	If fishing for fish were to be prohibited during the 30 warmest days of the year would you	N/A	Fish less that year, Reallocate your effort to other periods of the year, Reallocate your effort to other species, Fish in another region, Other
	27	Please answer the following questions with the fish you chose in mind.	I believe that the provincial government has provided sufficient resources to successfully manage fish populations in BC, I believe that the provincial government has implemented the necessary regulations to successfully manage fish populations in BC	Strongly agree, Agree, Neither, Strongly disagree, I don't know
	28	Do you believe that the federal government ought to be involved in the management of fish populations in BC?	N/A	Yes, No, I don't know
	29	Please indicate your level of agreement or disagreement with the following statement:	I believe catch and release practices are an effective way to ensure conservation of angled fish species	Strongly agree, Agree, Neither, Strongly disagree, I don't know
	34	Please indicate the likelihood that you would perform the following:	I am willing to voluntarily limit air exposure to ten seconds or less, I am willing to voluntarily limit air exposure completely (no out-of-water photos)	Very likely, Likely, Neither likely nor unlikely, Unlikely, Very unlikely, I don't know
	35	If limiting air exposure completely was mandatory (no out-of-water photos), would you still go fishing as often as you do now?	N/A	Yes, No, I don't know

Question 11 asked respondents to describe the frequency of their participation in various fishing types in different waterbodies, and Question 12 asked respondents to identify their preferred fishery in different waterbodies. Based on the terms used in Question 11, responses to fishing activity type were sorted into one of two categories: gear generalists and gear specialists. Specifically, we defined fly fishing as a technique that employs an artificial fly cast with a specialized rod and line, trolling as a technique where fishing lures or bait pulled behind a moving boat, spin fishing as a method of casting an artificial lure or bait and actively retrieving to entice a fish to bite, and drift fishing as a river technique where a float or just a weighted lure or bait is passively drifted downstream. Drift fishing is commonly an activity involving fly fishing, and trolling is commonly a subset of spin fishing. However, it was possible that either trolling or drift fishing could have been mistaken for one another by respondents. As such, the generalist gear type was assigned to those respondents that selected both fly and spin fishing activities or three or more gear types (i.e., not combinations of fly and drift, fly and troll, spin and drift, or spin and troll). Gear specialists were those who reported only fly fishing or spin fishing, or any one of the exceptions above.

A similar approach was used to develop the angler location type because the boundary of the definition between large and small lakes was sufficiently abrupt that the two types could potentially be confused with one another in medium-sized lakes. Anglers were asked to describe their fishing frequency in rivers and streams, small-sized lakes, large-sized lakes, and marine coastal areas. Location specialists were therefore identified as those anglers using either rivers and streams or lakes or marine coastal areas. Location generalists were those using more than one location type or more than two location types if both small and large lakes were selected.

A frequency angler type was created according to whether anglers fished often or very often (for any category) or fished sometimes or rarely. We assigned anglers who fished often or very often (which were subjective; i.e., no indications were given) as 'avid', while those who fished rarely or sometimes were assigned to the 'hobby' category. It should be noted that the use of the term 'avid' here applies to frequency only, not the degree of dedication to the activity. Lastly, the fishery angler type was created by separating responses according to whether respondents indicated they preferred fishing for rainbow trout or for steelhead.

Analysing responses by angler type

Since each respondent was assigned one of two possibilities for each angler type, analysis of responses by all features simultaneously would have contradicted any model requirements based on independence (i.e., a single respondent would contribute to more than one count per contingency table). Additionally, the Likert and Likert-type response data indicated that models treating data as ordinal would be favourable, with ordinal regressions (Bürkner and Vuorre, 2018). A two-way repeated measures ordinal regression with a cumulative link mixed-model was therefore used for analysis as this model is ideal for the paired measures generated by multiple answers per respondent (Mangiafico, 2016). This model was run such that respondent number was used as a random effect. A null model with no fixed effects was compared to the test model using the nagelkerke function from package rcompanion to generate pseudo R squared and p values for the model (Mangiafico, 2016), and a fixed model was used to determine the effect of the random variable. Regression model assumptions were checked using nominal and scale tests. Significant differences amongst angler types were analysed *post hoc* using emmeans pairwise tests (formerly lsmeans, Mangiafico, 2016). Responses were treated as ordered, numeric data for these comparisons. On occasions where model assumptions were not met, the model failed to converge adequately, or response types were not comparable to other questions, a one-way repeated measures ordinal regression was performed on

each question. Where neither approach was appropriate, only summary statistics are provided. All analyses were carried out in R, and required use of the psych, ordinal, car, RVAideMemoire, multcompview, emmeans, and rcompanion packages (R Core Team, 2019; R Studio Team, 2020).

Demographic variable analysis by angler type

To determine whether there were any demographic patterns across angler types, demographic variables were treated as predictor variables and angler type variables were treated as outcome variables. Associations were analysed using either Cochran-Mantel-Haenzel (CMH) tests in conjunction with Woolf tests, or Pearson's Chi-Squared tests on counts for each angler type. Due to the multiple tests being run on each demographic variable (4 tests per variable, 1 for each angler type), a Bonferroni correction was applied to adjust the p value (0.05/4 tests = 0.0125). Thus, only p values of 0.0125 or smaller were considered statistically significant. Tukeys HSD testing was used *post hoc* for significant ANOVA test. All descriptive and quantitative analyses used the basic stats package in R, R Studio Version 1.3.959 (R Core Team, 2019; RStudio Team, 2020) and CMH testing processes used the vcd package (Meyer et al., 2020) in Rstudio (R Studio Team, 2020). All tests for statistical association were two-tailed.

Open-ended question analysis

There were 21 questions or portions of questions that offered respondents opportunities to respond in their own words. All analyses for open-ended questions were performed in a similar manner, except for responses to Question 24. First, unintelligible or irrelevant responses were removed prior to coding, ranging from 0.5 % to 1 % of responses. Usable responses were then coded according to response type, depending on the nature of the question. For example, for open-ended questions related to satisfaction, responses were coded according to whether those responses could be viewed as internally or externally based satisfaction. Then, a second round of coding was conducted to distinguish the nature of the responses more clearly. Open-ended questions that were similar in content (e.g., Questions 20 and 21; Table 1) often contained responses to different segments in a single response or referred back to each other. For this reason, the coding for these questions is the same. Responses to Question 24 were difficult to evaluate in an individual manner and were coded as a whole. Following the initial coding by the lead author, co-authors participated in a coding validation exercise in which they re-coded (using the codes developed by the lead author but without access to the preliminary choices) a subset of responses to each question. Any discrepancies were resolved by choosing the code identified by the majority of authors. Once coding was finalized, responses were analysed for the entire respondent group using summary descriptive statistics only, as repeated measurement analysis for such data could not be adequately parameterized in count form to analyse per angler type. Quote examples are provided for each section and were chosen from responses at random using a random number generator.

Results

Summary of responses

Our broad estimate of the potential size of the rainbow trout and steelhead angling population in BC suggested there was a potential pool of 219,493 anglers who might have completed this survey. A total of 1170 individuals accessed the survey link and viewed the survey, an estimate of 0.5 % of the total BC *O. mykiss* angling population, with a survey completion rate of 85 %. Of the 1170 viewed surveys, there were 1052 surveys that were sufficiently complete for analysis. Of these, 23 respondents had failed to identify a fishery of focus. The decision was made to eliminate these 23 surveys as it was impossible to determine which fishery their responses pertained to (a crucial instruction throughout the survey) and because the primary analyses hinged on this differentiation as a part of angler type. The remaining 1029 surveys were included in the analysis; however, the number of usable responses varied per question (see Supplemental Materials Table 1 for total number of usable responses for each question).

Angler types

Demographic variables did not vary significantly amongst angler types, with one exception, indicating that significant differences found in type-based analysis would not arise as a result of demographic differences (Fig. 1; see Supplementary Materials starting page 30 for details). The number of respondents who identified as rainbow trout anglers was 883, while 146 respondents angled steelhead (Fig. 1). The average age of rainbow trout angler respondents (54.6; fishery type) was older than the average age of steelhead angler respondents; however, given the relative similarity in both average ages, we concluded that there were no meaningful demographic differences across angler type variables: gear, location, fishery, and frequency. We were unable to statistically analyse the impact of gender identification due to lack of diversity amongst respondents (94 % of respondents identified as male). The four angler types had uneven representation in the dataset: 709 respondents were categorized as gear specialists, 264 as gear generalists, 327 as location specialists, 679 as location generalists, 866 as rainbow trout anglers to 143 as steelhead anglers, 819 as hobby anglers, and 190 as avid anglers.

Beliefs: motivation, social factors, satisfaction, hatchery knowledge, and best practices

The most popular motivations to fish as described by respondents (in order of popularity) were spending time outdoors (735 respondents strongly agreed, 266 respondents agreed), relaxation (634 respondents strongly agreed, 332 respondents agreed), and spending time with others (230 respondents strongly agreed, 448 respondents agreed; Fig. 2). Fishing for food and trophy fishing were the least common motivations, with 411 respondents and 330 respondents respectively strongly agreeing or agreeing with these motivations, respectively. Of the 1029 responses, 750 respondents described fishing as their favourite leisure activity (400 strongly agreed, 350 agreed), while 821 respondents described fishing as a big part of their lives (450 strongly agreed, 371 agreed; Fig. 2). Responses to Question 8 (motivation and social factors) were mixed, with 80 anglers strongly agreeing and 273 agreeing they shared angling photos on social media, while 203 were

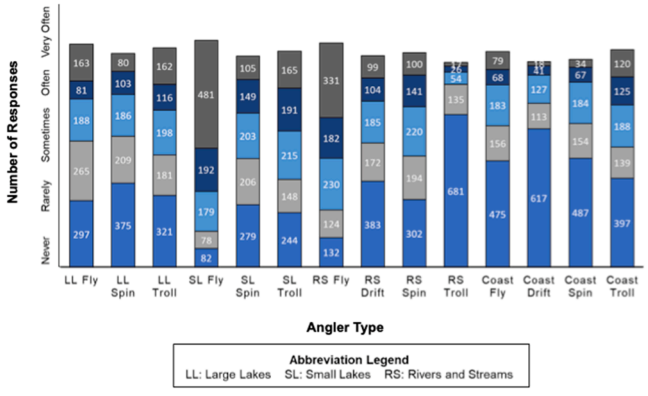

Fig. 1. The count of responses for answers toasking anglers to describe the frequency of their participation in fishing activities with different gear types (fly, spin, drift, troll) in different locations (large lakes [LL], small lakes [SL], rivers and streams [RS], and coastal areas [Coast]; Question 11). Respondents chose amongst Likert-type answers, 'never', 'rarely', 'sometimes', 'often', and 'very often'.

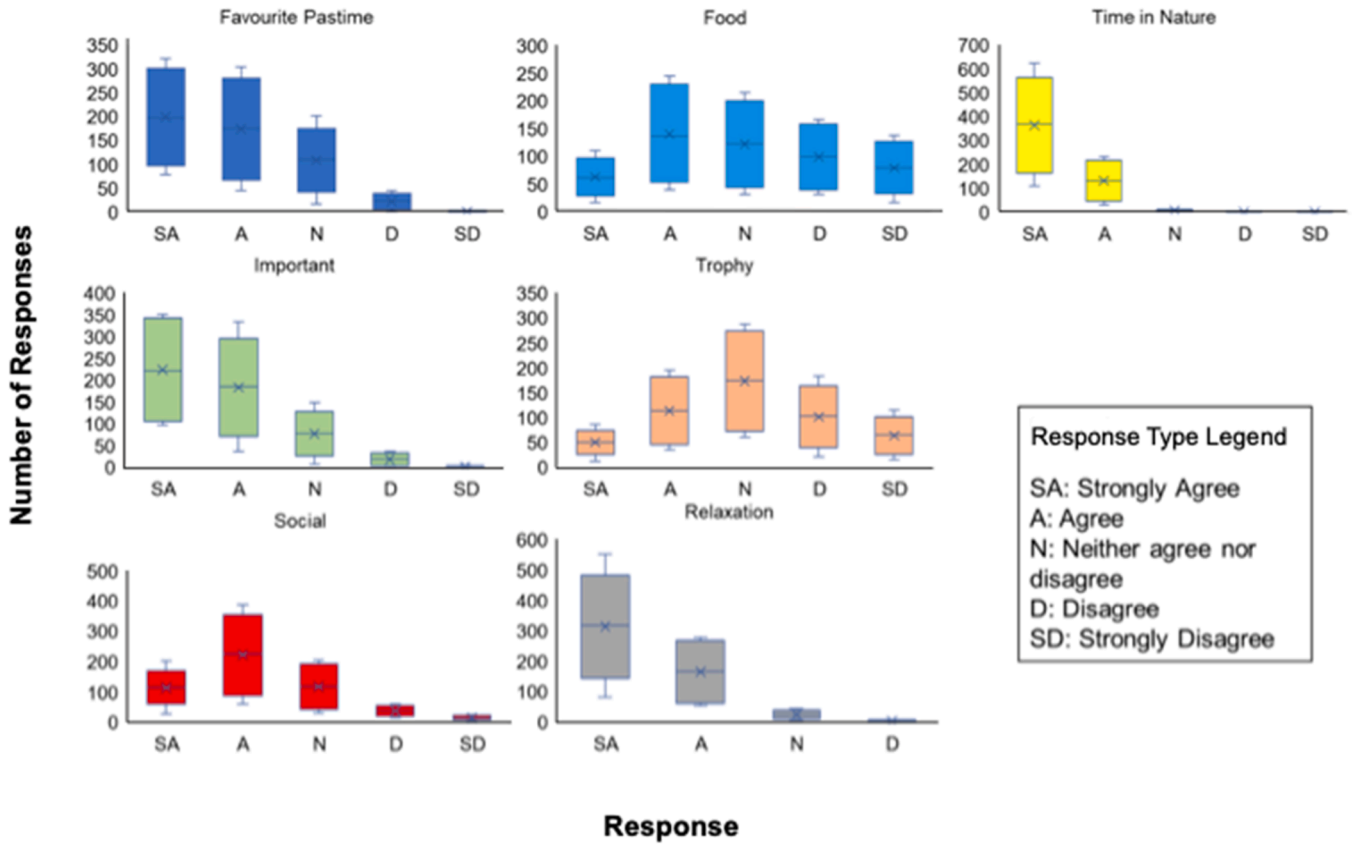

Fig. 2. Box plots of the total responses to Likert-type questions asking respondents to describe their level of agreement with suggested motivations for fishing, from left to right, top to bottom: favourite pastime (fishing is my favourite leisure activity), food (I fish for food), time in nature (I fish to spend time outdoors), important (fishing is a big part of my life), trophy (I fish to catch trophy fish [large or heavy]), social (I fish to spend time with others), relaxation (I fish to relax; Question 8). The mean reflects the total number of responses for that category, while the limits indicate the range of responses when separated by the different angler types.

neutral (neither agreeing nor disagreeing) and 230 disagreed. Respondent anglers' social circles were heavily involved in fishing, where 719 of 1020 indicated fishing was very important or important to the respondent's social circle. Most respondents did not derive the majority of their satisfaction in fishing activities from the number of fish they caught (899 responded 'No'), nor by not catching any fish at all (632 responded 'No'). Most respondents felt they could adequately distinguish between hatchery and wild fish (744 of 896 responses), and 226 of 702 respondents indicated that they treated wild and hatchery fish differently. Regarding angling knowledge and behaviour on the water, anglers felt that they worked to minimize air exposure (867 responses suggested they did to 14 that suggested they did not); however, there were also 142 anglers who declined to answer the question. When asked whether they would harvest fish that were unlikely to be released in good condition, 362 respondents suggested they would, 168 suggested they would not, 337 noted it would depend on other factors, and 140 declined to respond. When asked if they felt they actively participated in conservation or responsible angling activities in BC, 492 of 887 responding anglers felt that they did.

Beliefs by angler type

All angler types disagreed with the statement that they would be dissatisfied with a fishing trip if they did not catch any fish. Similarly, all angler types agreed that the number of fish caught was not an important source of satisfaction to them ('No' response). There were significant interactions between the motivators and angler types ($\chi^2 = 239.14$, $p < 0.0001$, model < 0.001, Pseudo $R^2 = 0.41$, random variable effect, $p < 0.0001$). These significant interactions were driven mainly by the avid angler type who disagreed with the fish as food motivator compared to gear generalists ($z = -7.5$, $p < 0.0001$), hobby anglers ($z = -5.9$, $p < 0.0001$), rainbow trout anglers ($z = -5.4$, $p = 0.0001$), and location specialists ($z = -6.1$, $p < 0.0001$). There were no significant interactions amongst angler types and social factors, nor amongst angler types and sources of satisfaction. There were significant interactions between the knowledge and best practices responses and angler types though the effect size was small ($\chi^2 = 97.73$, $p < 0.0001$, model < 0.001, Pseudo $R^2 = 0.15$, random variable effect, $p < 0.0001$). Significant differences in response to the question of being able to recognize hatchery and wild fish occurred between the rainbow trout angler type, who answered 'No' more frequently than location generalists ($z = 22.5$, $p < 0.0001$), gear specialists ($z = -26.2$, $p < 0.0001$), and avid anglers ($z = -24.0$, $p < 0.0001$).

Contextual responses to belief questions

Wild versus hatchery fish
"*They are all fish.*"- *survey respondent 180*

Respondents were more likely to frame their answers from an action perspective (187 responses), followed by an ethical perspective (89 responses) and a knowledge perspective (82 responses). Referring to catch-and-release was the most common action response nature (60 responses), followed by opting to harvest hatchery fish at 53 responses. In the ethics type responses, "treat all fish with respect" was the most common response nature at 44, followed by responses indicating that both wild and hatchery types have intrinsic value at 21 responses. Finally, regulations were most likely to dictate responses for knowledge type responses (31 responses), followed by responses describing

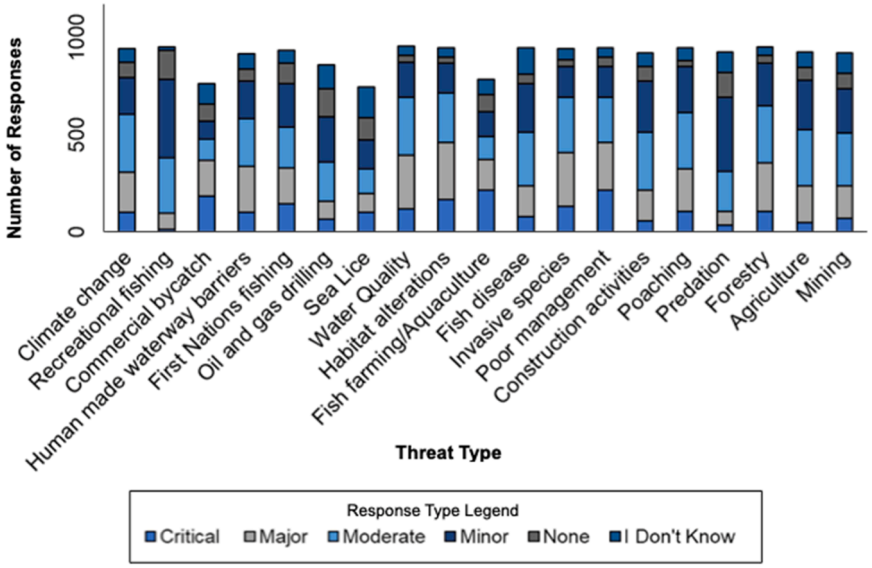

Fig. 3. Proportional representation of respondents' perceptions of threats to the health of their favoured fishery (Question 15). Respondents categorized each threat on a scale ranging from 'critical' to 'none'.

conservation concerns at 20 responses.

Activities supporting responsible angling

"*If I encounter other anglers, I kind of check what they are doing, and I usually talk to the tourists if they have questions about the regulations which are a total mess. If you are not from the area, you have no clue of what they are talking about.*"- *survey respondent 599*

Formal action-based responses were the most common, at 138 responses, while personal action-based responses had 126 responses, and ethically based responses were far rarer, at 19 responses. The majority of respondents referred to participation in formal groups or organizations as indications of their actions (Formal, 81 responses), followed by references to educating others (Personal, 44 responses) and participation via employment or volunteerism (Formal, 33 responses).

Threat perceptions: risk status, climate change, and self-identified risks

Most respondents (256 strongly agreed, 355 agreed) felt that their favoured fishery in BC was at current risk of decline, compared to 132 respondents who disagreed and 42 respondents who strongly disagreed. Similarly, most respondents felt their favoured fishery was at risk of future declines (226 strongly agreed, 297 agreed), compared to 147 respondents who disagreed and 51 who strongly disagreed. Overall, habitat alterations, poor management, invasive species, water quality, and fish farming were perceived (in this order) as the primary threats to steelhead and rainbow fisheries in BC. Sea lice, recreational fishing, and predation were viewed as the least significant threats (rank 17, 18 and 19 respectively; Fig. 3). Of the 969 respondents, the majority believed water temperatures in their fishery area had increased over the past ten years (564), while 404 did not perceive any changes. Specifically, of the 404, 184 experienced no change and 220 of the respondents were uncertain. Of the 957 respondents, the majority believed that water temperatures in their fishery will increase in the next ten years (564), while 365 said that it would stay the same or were unsure (185 and 200, respectively) and a small minority believe water temperatures will decrease (7). When asked specifically about climate change, 352 respondents believed climate change in BC is a very serious problem, while 429 respondents believed it was somewhat serious and 168 respondents believed it was not a problem at all. A stronger proportion disagreed with the statement that their BC fishery would never be impacted by climate change (454 strongly disagreed and 269 disagreed versus 46 strongly agreeing and 133 agreeing). A minority of respondents (46 strongly agreed and 133 agreed) believed climate change would not impact their BC fishery for many years; a statement 273 respondents disagreed with, and 290 respondents strongly disagreed with.

Threat perception by angler type

Steelhead anglers displayed significant differences in responses amongst angler types to threat perception questions. The major differences in both the current risk and future decline responses ($\chi^2 = -306.6$, $p < 0.0001$, model < 0.001, Pseudo $R^2 = -0.24$, random variable effect, $p < 0.0001$) were driven by the differences between the steelhead group and all other angler types. On the question of current risk, steelhead anglers chose 'Strongly agree' more often than gear generalists ($z = -4.5$, $p = 0.001$), gear specialists ($z = -4.9$, $p = 0.0001$), location generalists ($z = -4.$, $p = 0.007$), location specialists ($z = -5.3$, $p < 0.001$), avid anglers ($z = -4.5$, $p = 0.001$), hobby anglers ($z = 4.3$, $p = 0.001$), rainbow trout anglers ($z = 3.4$, $p = 0.05$). For the question of future decline, steelhead anglers again chose 'Strongly agree' more often than gear generalists ($z = -4.7$, $p = 0.0003$), gear specialists ($z = -4.6$, $p = 0.0004$), location generalists ($z = -4.0$, $p = 0.007$), location specialists ($z = -5.3$, $p < 0.001$), hobby anglers ($z = 4.5$, $p = 0.0006$), and rainbow trout anglers ($z = -4.7$, $p = 0.0003$). Steelhead anglers chose 'Minor' and 'None' when describing commercial bycatch as a threat to their preferred fishery ($\chi^2 = 195.1$, $p < 0.0001$, model < 0.001, Pseudo $R^2 = 0.1$, random variable effect, $p < 0.0001$), different from gear specialists ($z = -5.9$, $p < 0.0001$), gear generalists ($z = -5.2$, $p = 0.0002$), location specialists ($z = -6.1$, $p < 0.0001$), location generalists ($z = -5.5$, $p < 0.0001$), rainbow trout anglers ($z = -5.3$, $p < 0.0001$), and hobby anglers ($z = -6.3$, $p < 0.001$). Steelhead anglers were also more likely to choose 'Critical' for the threat 'Poor management' compared to rainbow trout anglers ($z = -4.5$, $p = 0.007$). Finally, steelhead anglers were less likely to choose 'Moderate' and more likely to choose 'Minor' as the threat ranking for 'Recreational fishing' than all other angler types: gear specialists ($z = 5.6$, $p < 0.0001$), gear generalists ($z = 4.9$, $p = 0.001$), location specialists ($z = 6.9$, $p < 0.0001$), location generalists ($z = 4.6$, $p = 0.003$), rainbow trout anglers ($z = 6.7$, $p < 0.0001$), avid anglers ($z = -4.1$, $p = 0.03$), and hobby anglers ($z = -5.8$, $p < 0.001$).

Contextual responses to threat perception questions

Main threats to rainbow trout and steelhead

"*Commercial fishers who catch everything, including steelhead"- survey respondent 911*>

Respondents often viewed the same response such as habitat loss, from varying perspectives and were concerned about different sources of these problems. Four respondents each indicated that there were either no threats to BC fisheries or that there were too many threats acting in concert to single out one. Responses to Question 15 (In your opinion, what is the biggest single threat to [rainbow trout or steelhead] populations in British Columbia?) were separated into one of four types: environmental (230 responses), within the recreational fishery (254 responses), intersectoral (other fisheries or recreational water users; 220 responses), and industry or infrastructure (143 responses). The most common individual response codes, however, were seeing other sectors (external to the recreational fishery; primarily commercial and First Nations fisheries and aquaculture) as the most pressing threat to BC fisheries at 175 responses, followed by poor behaviour from other anglers (internal to fishery; primarily poaching and overfishing) as the most pressing threat to BC fisheries at 124 responses, and management and capacity (primarily mismanagement and poor management by both provincial and federal governments) as the most pressing threat to BC fisheries at 120 responses.

Action perceptions: management capacity, closures and other management measures, and willingness to change

Overall, respondents did not feel that the BC provincial government provides sufficient resources to manage their fishery (369 strongly disagreed and 259 disagreed) or has implemented necessary regulations to manage their fishery (246 strongly disagreed and 237 disagreed). Respondents also did not support the involvement of the federal government in regulating BC fisheries, with 515 respondents indicating the federal government should not be involved, to 259 indicating that they should be involved. Respondents showed higher support for specific management actions than involvement of management bodies. For example, three quarters of respondents agreed or strongly agreed (363 and 305, respectively) that catch-and-release is an effective management tool for conservation and that 'catch-and-release only' measures where no harvest is allowed were considered the most effective management tool of all (417 very effective, 355 somewhat effective). After catch-and-release, respondents viewed (in order) daily catch limits, gear restrictions, and annual harvest limits as the most 'very effective' management measures. Seasonal closures and yearly catch limits were the least popular measures, but still considered 'somewhat effective' more often than 'not effective'.

Respondents tended to assess their own behaviours and attitudes positively – seeing their own behaviours as benign or exhibiting a willingness to change. When asked if they were likely to change their fishing behaviour if scientific studies showed that minimizing air exposure of fish caught in high water temperatures led to reduced mortality for released fishes, 216 respondents suggested they would do so. A further 590 respondents indicated that they already performed this behaviour. Similarly, when asked if they were likely to change their fishing behaviour if scientific studies showed that the frequency or duration of fishing trips should be reduced during periods of high water temperatures, 301 respondents indicated they would make the change while an additional 437 respondents indicated that they already performed this behaviour.

When asked if they were likely to use a 'de-hooking' device on their next fishing trip, 451 respondents indicated they would do so voluntarily, 330 respondents indicated that they already used a 'de-hooking' device, 59 respondents indicated they would use such a device if regulations required it, and 78 respondents indicated they would be unwilling to use such a device. When asked if they would fish as often as they do now if limiting air exposure completely was mandatory, 819 respondents chose 'Yes' and 35 chose 'No'. When asked what they would do if their preferred fishery were closed during the 30 warmest days of the year, 186 respondents suggested they would reallocate their fishing effort to other times of year, 185 respondents suggested they would fish less that year, 121 respondents suggested they would fish in another region, and 102 of respondents suggested they would reallocate their fishing effort to other species.

Action perceptions by angler type

Angler types held different views on fishery closures ($\chi^2 = 23.7$, $p = 0.05$, model $p < 0.0001$, Pseudo $R^2 = 0.04$, random variable effect, $p < 0.0001$), driven by comparisons between location identities and steelhead anglers, though the effect size was negligible. Location generalists chose 'Somewhat effective' more often than location specialists ($z = 4.2$, $p = 0.007$) when discussing summer closures. When discussing summer closures, steelhead anglers were more likely to choose 'Very effective' than location specialists ($z = -3.9$, $p = 0.02$) when discussing spring closures and more likely to choose 'Somewhat effective' than location specialists ($z = -4.8$, $p = 0.0004$). The model exploring catch limit perceptions also found significant differences amongst angler types ($\chi^2 = 81.7$, $p < 0.0001$, model $p = 0$, Pseudo $R^2 = 0.15$, random variable effect, $p < 0.0001$). Steelhead anglers differed from location specialists ($z = 4.6$, $p = 0.003$), rainbow trout anglers ($z = 4.4$, $p = 0.006$), and hobby anglers ($z = -4.0$, $p = 0.04$) by choosing 'very effective' more often when discussing daily catch limits. All angler types except steelhead anglers indicated they would reallocate their efforts to other years and would fish less, while steelhead anglers indicated they would reallocate their efforts to other species (Fig. 4).

Contextual responses to action perception questions

Federal management

"*How does the rest of the country know what is good for BC fish?" -survey respondent 409*

There were 552 usable responses to Question 28 (Do you believe that the federal government ought to be involved in the management of fish populations in British Columbia?) that were coded into four response types: trust-based, governance-based, unity theme, and 'appropriate scale of government' theme. The trust theme was the most common in the responses (731 responses), followed by scale (678 responses), governance (441 responses) and unity (334 responses). The mistrustful code was the most common in the trust category and overall, at 672 responses. The scale-based responses suggesting management was a BC responsibility was the next most popular at 291 responses, followed by the unity themes 'management should be a shared responsibility' at 254 responses.

Efficacy of protection measures

"*When ice fishers hear of a good lake to fish they target it heavily until it's (sic) fish populations are decimated." – survey respondent 276*

Responses to Question 24 (in your opinion, how effective are the following measures at protecting [rainbow trout or steelhead] populations: winter closures, spring closures, summer closures, yearly catch limits, gear restrictions, annual harvest, catch-and-release only?) were categorized into three types: for, against, and other/nuanced. Many steelhead anglers noted that there is a winter fishery for steelhead, which impacted their responses for the winter closures segment of

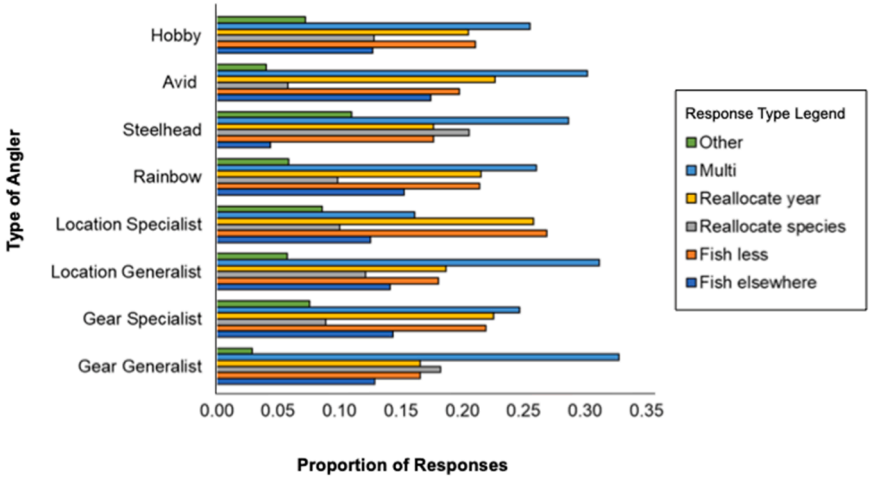

Fig. 4. The proportion of responses per angler type to the question asking respondents how they would adjust their behaviour if fishing were prohibited on the 30 warmest days of the year: fish less that year (fish less), reallocate your effort to other periods of the year (reallocate year), reallocate your effort to other species (reallocate species), fish in another region (fish elsewhere), other (i.e., open ended response to provide context), and multiple response (Multi; Question 26).

Question 24. Responses categorized as 'other' type were most common at 147 responses, followed by those coded as 'for' at 170 responses, and those coded as 'against' at 121 responses. The most popular codes were 'this action is harmful' at 62 responses ('for'), followed by 'this measure doesn't apply to/impact me' ('other') at 52 responses. Responses coded as 'good for the fish/fishing' ('for') and 'reduces pressure' ('for') each had 50 responses.

Attitudes towards changing fishing behaviour

"*Keep them wet. catch-and-release with release nets, barbless hooks. every precaution taken to have a successful release" – survey respondent 227*

The responses for Question 20 (If scientific studies were to show that minimizing air exposure of fish caught at high water temperatures reduces the likelihood of mortality, would you change your fishing behaviour in any way?) were categorized into action type, change type, ethic type, and knowledge type responses. Action type responses were by far the most common category at 351 responses. This category consisted of response codes: I already do this action, I catch-and-release (without specific reference to air exposure or other behaviours), I fish for food, I do other action instead (referring primarily to reducing or stopping fishing activity in high temperatures). Knowledge type responses were the next most common at 61 responses and consisted of a mix of codes: the disagree code included those responses disagreeing that air exposure was an issue, disagreeing with the nature of the question (a variation on 'this question is dumb'), and disagreeing with the value of science in general. The random fact code mainly consisted of responses such as 'fake news' and 'climate change is a hoax'. The 'I don't understand' code was reserved for respondents who claimed not to understand the concept involved in the question, and the 'understand' code consisted of responses claiming to understand the action, though this code did not differentiate correct understanding from incorrect understanding. The ethics type of response was the third most frequent at 47 responses. It included responses suggesting any action was worth it for the sake of the fish (do anything), responses suggesting everyone should minimize air exposure, responses suggesting that everyone should prioritize some other action, and responses suggesting that minimizing air exposure is important or the right thing to do. The change type was the least common response type at 28 responses and consisted only of those responses suggesting that the change would be made, and those suggesting some other change would be made in those circumstances.

Discussion

Research on angler behaviour has shown that anglers are a heterogenous population with diverse views on fisheries management issues (Fisher, 1997; Post et al., 2008; Hasler et al., 2011). Our results show that using an angler type approach can contextualize similarities and differences in angler perspectives, which can inform management strategies. While many of the differences we found were intuitive and some effect sizes small, that should not be taken to mean these varying responses are not important. By contrast, what the differences show is that viewing results through the lens of angler choice and behaviour is a good way to understand the rationale for these finer differences. In doing so, researchers, policy makers, and decision makers may be able to better understand different segments of the angling population.

Results of the survey showed that angler types share many of the same motivations for engaging in fishing behaviours and similar concerns regarding threats to their preferred fishery. Differences were evident across angler types on issues related to angler behaviour, as well as views on effective management of the fisheries, often due to differences in preferred fishery. Additional key findings include the need to address intersectoral relationships in BC fisheries that were identified in analysis of angler threat perception responses and the need for improved angler-management relationships identified in analysis of action perceptions. Further, while many responses identified issues commonly discussed in science communication and in fisheries literature such as habitat loss, the explanations provided in open-ended question responses clearly demonstrated wide variation in how these terms are understood. Collectively, all of these findings provide a more holistic image of the fishery than via descriptive statistics alone.

In exploring beliefs, the primary motivations for participating in fishing were 'fishing adjacent': time outdoors, relaxation, and spending time with others which align strongly with existing research on the psycho-social benefits on angling in that the sources of motivation and satisfaction mirror the benefits (e.g., Arlinghaus et al., 2007; Arlinghaus et al., 2019). This outcome could indicate that the majority of the respondent groups are not primarily orientated towards consumption (Fedler and Ditton 1986; Aas and Kaltenborn 1995); however, it should not be interpreted that catching fish is not important to anglers. On the contrary, consumption may be more important to anglers than it typically appears in our survey results (Graefe and Fedler 1986; Birdsong et al., 2021)

Question 15 clarified that the concerns about poor management recorded in Question 14 results were specifically directed to the management of recreational fisheries (for the majority), as this threat was

the most popular code. However, the most common individual codes (i.e., when not considering response type) showed that blame for other sectors (i.e., commercial fisheries, First Nations fisheries, and aquaculture) was considered the most prevalent threat, followed by poor behaviour from other anglers, and issues with management and capacity at both levels of government was third most popular. This finding aligns with research showing that anglers generally support restrictions of other resource users and uses (Aas and Kaltenborn, 1995). For example, in Norway, support for restricting other uses (i.e., leisure gill-net fishing) was based on wishing to reduce risk to fish populations via these other uses (Aas and Kaltenborn, 1995). However, anglers generally do not support any actions that would potentially restrict their access (Aas and Kalternorn, 1995) including for establishment of protected areas (Danylchuk and Cooke, 2011), suggesting that anglers are not likely to view their fishing activities as a threat to fish. Indeed, angler buy-in for conservation is more likely if threats to the resource originate from outside the fishery (Cowx et al., 2010).

Our results also suggest that better communication is necessary for improving the angler-management relationship, not unlike the findings from global case studies (see Dedual et al., 2013). The negative perspectives of management bodies suggest that trust-orientated improvements can be made in this relationship, particularly in the arena of management actions and conservation benefit. Anglers indicated that they believe they are willing to act to support conservation and will accept certain restrictions to support fish populations, but they also show that they believe their current practices are sound and that they wish to know if any required changes are based on sound science. It is also clear that anglers disliked blanket actions, such as closing an entire management area when water temperature in a few waterbodies exceeds safe thresholds for fish survival post-release. The desire for specificity in management actions amongst anglers poses an enormous challenge to policy makers and managers, who are bound by legislative frameworks and mandates that require operation at feasible scales (e.g., managing at the ecoregional scale). Could this issue be resolved by building trust, and can that trust then be enacted through prioritising enforcement actions?

Several sources of systematic bias could have potentially impacted our survey and results. First, we employed a non-probabilistic sampling approach where the survey was broadcast via social media, paid targeted Facebook advertisements, and through our partner organizations (i.e., the Freshwater Fisheries Society of BC and Anglers Atlas), which likely resulted in high avidity biases (see Thomson, 1991). Nonetheless, non-probabilistic survey methods are regarded as a useful method for targeting recreational anglers (Howarth et al., Press). An additional source of bias could be derived from the individuals that did not respond to the survey, therefore introducing nonresponse bias (Connelly et al., 2000), where the collected data could differ from those who responded versus those who did not (Fisher, 1996). We did attempt to minimize nonresponse bias by only including response from surveys with higher completion rate (i.e., $<$90 %). It is also possible that the responses to our survey could have included social desirability bias, where respondents tend to choose responses they believe are more socially acceptable as opposed to reflecting their true thoughts or behaviour (Bergen and Labonte, 2020). Finally, an additional limitation could include recall bias which is common in self-reporting studies and stems from incomplete or inaccurate recollection of events (Chu et al., 1992); however, we did attempt to mitigate this by designing our survey to capture specific and complete information.

Future research seeking to understand and predict behaviour, or to encourage behavioural modification (e.g., nudges) would benefit from understanding the links between choice, behaviour, and identity, as how we perceive ourselves, our 'identity' or role in a given circumstance, is a strong determinant in how we feel and behave in that circumstance (Burke, 1991). Jun et al. (2015) argued that identity theory was a fruitful theoretical framework for understanding recreation choices and behaviours. Landon et al. (2018) explored differences in how identity and personal norms contributed to recreational fishing stewardship behaviours amongst Texan anglers and found that there were links between the angler identity and personal norms related to stewardship that influenced behaviour. While this area of study is underused in recreational fisheries, we recommend future work to include concrete exploration of angler identity as a platform and framework for understanding what facets of angler identity influence choices and behaviours, as such understanding is a useful tool for supporting meaningful conservation action.

Conclusion

Studies such as this can benefit fisheries management efforts as they provide a snapshot of a fishery through the lens of the fishery users. This research provides an overview of the heterogeneous groups of anglers making up the fishery, as well as their perspectives of current management efforts and potential future strategies. This information can be used to predict angler responses to management changes and suggests efforts to address identified mistrust and disappointment in current management bodies. By listening to angler perspectives and informing management decisions with such perspectives, management bodies in BC have the opportunity to improve relationships with anglers and develop strategies that are likely to be supported. Furthermore, communicating rationales behind decision-making processes and best practices with anglers can lower negative perceptions of fisheries management in the province which will likely benefit management bodies, fisheries users, and the fish they target in the long run.

CRediT authorship contribution statement

Shannon D. Bower: Writing – original draft, Visualization, Methodology, Formal analysis, Data curation. **Amanda Jeanson:** Validation, Project administration, Data curation, Conceptualization. **Jessica A. Robichaud:** Writing – review & editing. **Morgan L. Piczak:** Writing – review & editing. **Nathan Young:** Writing – original draft, Supervision, Project administration, Conceptualization. **Adrian Clarke:** Writing – original draft, Supervision, Project administration, Conceptualization. **Andy J. Danylchuk:** Writing – original draft, Supervision, Project administration, Funding acquisition, Conceptualization. **Steven J. Cooke:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on reasonable request.

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Supplementary materials

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