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EDITED BY
Pablo Pita,
University of Santiago de Compostela, Spain

REVIEWED BY
Martín Laporta,
Dirección Nacional de Recursos Acuáticos, Rocha, Uruguay
Raquel De La Cruz Modino,
University of La Laguna, Spain

*CORRESPONDENCE
Kayla M. Hamelin
kayla.hamelin@dal.ca

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"The people's fish": Sociocultural dimensions of recreational fishing for Atlantic mackerel in Nova Scotia

Kayla M. Hamelin[1,2]*, M. Aaron MacNeil[1], Kaitlyn Curran[2] and Megan Bailey[2]

[1]Ocean Frontier Institute, Department of Biology, Dalhousie University, Halifax, NS, Canada, [2]Marine Affairs Program, Dalhousie University, Halifax, NS, Canada

Atlantic mackerel or Amalamaq (*Scomber scombrus*) has been subject to diverse fishing pressures in Atlantic Canada for commercial, bait, recreational, and Indigenous food-social-ceremonial (FSC) fisheries, resulting in its substantial social and cultural significance in the region. Recent stock declines have led to closures of the commercial and bait mackerel fisheries, while recreational and FSC harvesters retain respectively the ability or right to fish. Here we assess the human dimensions of the recreational mackerel fishery through administration of a voluntary questionnaire shared at wharfs and through online/social media channels. A total of 285 responses were received, with results providing a rich picture of this poorly-engaged stakeholder community. The operational dimensions of this fishery and benefits derived from recreational fishing are explored. While recommendations for conservation and management measures were not solicited explicitly, many respondents shared comments and suggestions regarding management of the stock. Engaging more actively with recreational mackerel anglers may allow for enhanced assessments of the fishery and foster local stewardship toward more effective fisheries management.

KEYWORDS

sustainability, human dimensions, recreational fishing, angling, fisheries management, social-ecological systems, ecosystem services

Introduction

The overarching goal of fisheries management is often stated simply as 'sustainability'. For some time, it has been acknowledged that fisheries represent complex social-ecological systems (Charles, 1994; Charles, 1995; McLeod and Leslie, 2009; Link et al., 2011; Fogarty, 2014; Long et al., 2015), and thus sustainability can be understood to involve multiple dimensions including ecological, economic, social (including cultural), and institutional (or governance) pillars (DeYoung et al., 1999;

Stephenson et al., 2017; Foley et al., 2020). Indeed, these multiple components are often included in frameworks in support of ecosystem-based management (EBM), an approach many jurisdictions are in the process of formally adopting (Marasco et al., 2007; DeYoung et al., 2008; Garcia et al., 2014; Long et al., 2015; DePiper et al., 2017). However, many fisheries assessments, including those in Canada, still focus largely on the biological or ecological and, to a lesser extent, economic components of the coastal and marine systems within which fisheries operate (Charles, 1994; Charles, 1995; Ommer et al., 2012; Urquhart et al., 2013; Stephenson et al., 2019; Paul and Stephenson, 2020).

Reliance solely on population or bioeconomic assessments may result in fisheries management decisions that ignore important cultural and social objectives (Fowler et al., 2022). For example, core social objectives identified by the collaborative, multi-stakeholder Canadian Fisheries Research Network (Stephenson et al., 2019) included sustainable communities, health and well-being, and ethical fisheries. Socio-cultural benefits from fisheries may also be defined using an ecosystem services framework, with 'cultural services' comprising culture and amenity, recreation, aesthetics, and education and research (UNEP, 2006; McLeod and Leslie, 2009). So-called 'human dimensions' research is the key to capturing these aspects of fisheries, allowing for an understanding of human cognitions, behaviours, and relationships related to fishing and fisheries governance, and consequently the mapping of links and feedbacks between both the human and natural components of the system (DeYoung et al., 2008; Hunt et al., 2013).

Although human dimensions research has been taking place since the 1960s, and is on the rise in contemporary fisheries research (DeYoung et al., 2008; Bennett, 2019), recreational fisheries are generally understudied compared to commercial sector fisheries (Brownscombe et al., 2019; Cooke et al., 2019; Holder et al., 2020). The Food and Agriculture Organization defines recreational fishers as those that do not rely on fishing to supply a necessary part of their diet or income (FAO, 2012), and thus they fish for other benefits (e.g., cultural ecosystem services). There are several parallels between marine recreational fisheries and small-scale fisheries in the sense that they are often poorly defined, diverse in scope, and often not well represented in research and assessment procedures (Pita et al., 2020a; Pascual-Fernandez et al., 2020). In any case, without assessment of the full breadth of human-fish interactions within these socio-ecological systems, it is unlikely we will be able to achieve the goal of both sustainable ecological and human communities.

The Atlantic mackerel or Amalamaq (*Scomber scombrus*) fishery in Atlantic Canada operates in a complex socioeconomic seascape, encompassing the ancestral and unceded territory of the Mi'kmaq, Wolastoqey, Peskotomuhkati, and Beothuk who fished mackerel for millenia (Denny et al., 2020). Atlantic mackerel is a once-common forage fish that provides a critical intermediate link in the North Atlantic food web between small fish and invertebrates at lower trophic levels and top predators at higher trophic levels, including larger fish, birds, marine mammals, and humans (DFO, 2007; Van Beveren et al., 2017a). While Atlantic mackerel are found throughout the North Atlantic, the Northern contingent of the western Atlantic population is found largely within Canadian waters (Gíslason et al., 2020; Moura et al., 2020; Van Beveren et al., 2020). Unfortunately, after significant population declines in recent years attributed to overexploitation, and possible ecosystem changes or climate change impacts, the Canadian Department of Fisheries and Oceans (DFO) has assessed mackerel in the 'critical' zone under the Sustainable Fisheries Framework, meaning that the stock is below the defined Limit Reference Point and requires conservation action to rebuild the population (DFO, 2021).

However, Canadian mackerel stock recovery has been complicated by the fact that there are a variety of fisheries that target this stock with differing objectives (Figure 1) (DFO, 2007; Van Beveren et al., 2017a). The species continues to hold significance to Indigenous groups such as the Mi'kmaq (Denny et al., 2020), who retain Aboriginal rights and title to fishery resources (Wiber and Milley, 2007). Furthermore, there has been a commercial fishery harvesting mackerel for sale and export, supporting livelihoods across the region. There has also been a commercial bait fishery which harvests mackerel for use as bait in other commercial fisheries, including the multi-billion-dollar lobster or Jakej (*Homarus americanus*) industry (Fisheries and Oceans Canada, 2022), and as bait for bluefin tuna sport fishing. Finally, there is a long history of a culturally significant recreational fishery throughout the region (Brushett et al., 2019), with mackerel representing the second most frequently caught recreational species in the provinces of Nova Scotia and Prince Edward Island (DFO, 2015). Most recreational anglers fish for mackerel in coastal waters using a standard rod-and-reel fishing pole, typically with multiple hooks per line.

To address the precarious state of Atlantic mackerel, a combination of conservation measures has been put in place in recent years, most significantly the closure of the commercial and bait fisheries in spring 2022 (Government of Canada, 2022). Currently, FSC fisheries are allowed to continue uninterrupted, while recreational fishing is permitted with ongoing restrictions on the season, gear, minimum size, and number of fish able to be retained by recreational fishers (https://www.dfo-mpo.gc.ca/fisheries-peches/decisions/fm-2021-gp/atl-31-eng.html). There is neither a licensing requirement nor formal data collection (e.g., creel survey) for recreational mackerel fishing in the region, and thus it is challenging to know how many anglers are fishing and how many fish they catch. Data collection in recreational fisheries is notoriously challenging (Griffiths et al., 2017; Hyder et al., 2020) and, for many recreational fisheries in North America, recreational fishing is viewed as a public good

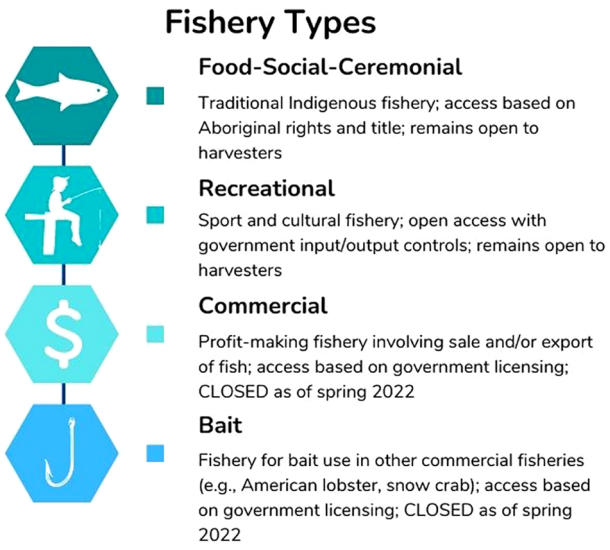

FIGURE 1
Summary of fishery types targeting Atlantic mackerel or Amalamaq (*Scomber scombrus*) in Atlantic Canada.

(i.e. open access) with less influence from managers on where and how often anglers fish (Cox et al., 2002; Daedlow et al., 2011; Hunt et al., 2021). Nevertheless, the recreational fishery now likely represents both the largest group of stakeholders interacting with Atlantic mackerel and the most valuable source of fishery-dependent data.

Human dimensions research on the recreational component of the mackerel fishery in eastern Canada has been much-needed, given that within fisheries management, recreational anglers are less frequently consulted than commercial fishers – likely due to difficulty in accessing individuals not represented by stakeholder associations, rather than a lack of willingness to participate (Hyder et al., 2020). Furthermore, while the number of recreational mackerel anglers in the region is presently unknown given the lack of licensing and data collection in the fishery, this community of under-engaged stakeholders might in fact be the most numerous, given the ubiquity of the activity in the region (Brushett et al., 2019), and the fact that globally, recreational anglers are considered significantly more numerous than commercial harvesters (Arlinghaus et al., 2019). Furthermore, there have been substantial economic, social, and cultural benefits from recreational fishing documented around the world (Cisneros-Montemayor and Sumaila, 2010; McManus et al., 2011; Arlinghaus et al., 2015; Griffiths et al., 2017; Arlinghaus et al., 2019; Hyder et al., 2020; Pita et al., 2020b), and it remains unclear which of these might be most relevant to mackerel anglers in our region.

The present study – conducted one year before the current commercial closure - focused on exploring the sociocultural and operational aspects of the recreational mackerel fishery. Using a questionnaire, we asked 1) who fishes for Atlantic mackerel for recreational purposes, 2) how they fish (i.e., an assessment of common practices and behaviours), and crucially, 3) why they fish for Atlantic mackerel, in order to determine sociocultural benefits (e.g., cultural ecosystem services) and who in the fishing community is likely to benefit in different ways. Just as a commercial industry might be jeopardized, these recreational benefits equally stand to be lost if the Canadian mackerel stock continues to decline, although it can be difficult to assign value to recreational fishing when considering management options because of a lack of methods to integrate cultural value into the current assessment process. Furthermore, while the focus of recent media attention in eastern Canada has, understandably, been on what is lost when a commercial fishery is closed (e.g., FFAW, 2022), here we investigated the benefits that are retained when traditional and recreational fisheries maintain access to their target species.

Methods

Data collection

The study population comprised adults (18+) of all backgrounds who 1) self-identified as recreational mackerel anglers and who 2) fish in Nova Scotia, Canada (Figure 2). Nova Scotia, a province known by the slogan "Canada's Ocean Playground" (Develop Nova Scotia, 2021), hosts a large number of recreational anglers, and has coastal access points in both rural areas and Halifax Regional Municipality (HRM;

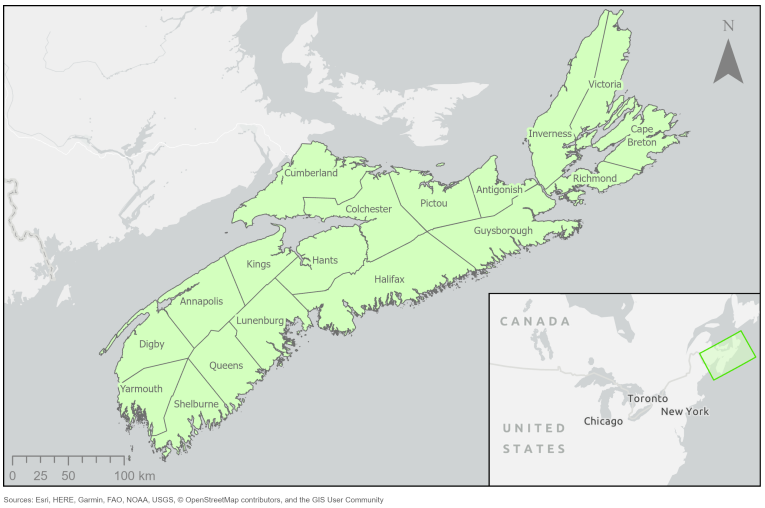

FIGURE 2
Map of Nova Scotia, the province in eastern Canada (located within the traditional and unceded territory of the Mi'kmaq and Wolastoqey) which compromised the geographic scope of recruitment for a research study on recreational mackerel fishing in the region. Solid lines delineate county borders within the province (Nova Scotia Geographic Data Directory, https://nsgi.novascotia.ca/gdd/).

K'jipuktuk), the capital of the province and the largest urban area in Atlantic Canada. The province has a population of approximately 923 598[1], of which approximately 83% are 18 or older[2], with a median age of 45.6 years[3]. The population of the capital of HRM represents approximately 48% of the provincial population[4]. The total number of recreational mackerel anglers within the province is unknown. A DFO report from 2015 estimates that there are 49 714 recreational anglers across all target species (freshwater and marine) in the province (DFO, 2015). However, these data are at least 7 years out-of-date, and the survey yielding the 2015 report was distributed primarily to anglers in licensing databases, which might not cover groups who target mackerel.

A voluntary questionnaire of 39 questions (Appendix A) was administered online using password-protected Opinio software, which provided an anonymous web link to open the survey. A 'cookies' feature was used to ensure only one submission was received per participant. Ethical approval was obtained from the Dalhousie University Research Ethics Board (2021-5622) and the survey included an introduction page outlining the objectives, risks, and benefits of the research and requesting the consent of participants before proceeding to the questionnaire. Our research questionnaire was offered in English, as this is the primary language understood by all members of the research team, and is the most commonly spoken language in the study region. While there was no compensation offered for participation, the chance to win 1 of 5 $100 Mastercard gift cards *via* random draw was offered as an incentive. Contact information for prize winners and for respondents interested in receiving a copy of research results was disaggregated from survey data to maintain anonymity.

Participants were recruited by distributing information cards with a survey link during dockside visits to known recreational fishing locations in HRM and opportunistically at fishing sites elsewhere in the province. Additional information cards were distributed to libraries, community centres, and outdoor sports shops throughout HRM. Although the survey was conducted in English, to convey project objectives and recruit individuals from diverse populations, some of the project summary information on the recruitment card was translated into French, Arabic, Mandarin Chinese, Spanish, Korean, and Hindi, representing additional significant language groups in Nova Scotia[5]. While we attempted to work with colleagues and collaborators to translate materials into Mi'kmaq, we were

1 https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/hlt-fst/pd-pl/Comprehensive.cfm

2 https://novascotia.ca/finance/stats.div/papers/demograf/demo4.htm

3 https://novascotia.ca/finance/statistics/news.asp?id=17752#:~:text=Nationally%2C%20median%20age%20increased%20from,over%20the%20last%20five%20years.

4 https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/hlt-fst/pd-pl/Comprehensive.cfm

5 https://www12.statcan.gc.ca/census-recensement/2011/dp-pd/vc-rv/index.cfm?Lang=ENG&VIEW=D&GEOCODE=12&TOPIC_ID=4

unable to do so for this study. While this was unfortunate, given our project goals around equity and inclusion, we acknowledge that most Indigenous individuals in Nova Scotia speak English (Nova Scotia, 2021), and thus it is unlikely this represented a language barrier.

The survey was shared online through social media accounts associated with this research project (@gofishns on Facebook and Instagram) to increase geographic reach around the province. In addition, the link was posted on relevant local fishing social media groups (e.g., 'Mackerel and Squid Fishing Nova Scotia' on Facebook), and sent to relevant organizations for distribution (e.g., Fishermen and Scientists Research Society, Nova Scotia Federation of Hunters and Anglers) to invite anglers from elsewhere in Nova Scotia to respond. The survey was also distributed *via* university channels, including the email list servs for the Dalhousie Department of Biology and the Marine Affairs Program, and was featured on the 'Today at Dal' news page.

Although these opt-in recruitment methods meant participants were largely self-selecting, the combination of recruitment *via* social media and recruitment in-person allowed for both access to a broad range of participants around the province, in addition to more personalized invitations to those who might be less familiar with social technologies. Survey invitations and information cards encouraged participants to request a paper copy of the survey if preferred, but no such requests were made and all submissions were received through the online Opinio platform.

Survey responses were collected between Monday June 14 and Friday October 8, 2021, which approximately corresponds to the primary recreational mackerel fishing season in Nova Scotia, based on previous survey work (Brushett et al., 2019). The questionnaire (see Appendix 1) was divided into two sections: 1) Fishing Activity and 2) Demographics. Within the Fishing Activity section, a combination of multiple-choice (MC) and open-ended (OE) questions were used to identify: experience with fishing (MC), target species of interest (MC/OE), locations of fishing activity (MC), additional types of mackerel fishing conducted (MC), years of experience (MC), fishing season (MC), frequency of fishing activity (MC), observed changes to size or abundance of fish (MC), observed changes to fishing regulations (MC), sharing of fishing data (MC), reasons for fishing (OE), consumption of mackerel (MC), importance of mackerel as food (MC), value of mackerel in diet (MC), financial valuation of mackerel as a food source (OE), importance of fishing activity (MC), social context of fishing (MC), personal effects if fishing were no longer possible (OE), and additional comments or concerns (OE).

Within the Demographics section, multiple-choice questions were be used to identify the region in which the participant resides, identity as an immigrant or refugee, ethnic identity, level of English proficiency, languages other than English used, gender identity, LGBTQIA2S+ identity, age, disability status, education level, income, and employment status and sector. In co-authoring this paper, our diverse positionalities reflect non-Indigenous, Canadian-born men and women, who are academic researchers and a health care professional, living with and without disability. At the end of each section (i.e., after 'Fishing Activity' mid-way through; after 'Demographics' at the end of the survey), there were opportunities for respondents to share any additional thoughts or ideas not captured by the structured questions. Providing open-ended questions was important to ensure respondents had opportunities for self-expression and to facilitate the solicitation of concerns or perspectives from the community unanticipated by the research team.

Analysis

A mixed-methods approach was used to analyze questionnaire responses. For demographic data, summary statistics (frequency counts and proportions [%]) were generated using Opinio software. It should be noted that sample size varied among questions because responses were not mandatory, and respondents varied in the number of questions answered. Furthermore, some multiple-choice questions allowed the respondents to 'check all that apply', and thus in those cases the counts reported always represent the number of selections, not the number of respondents. These data were compared with similar data from Statistics Canada (https://www.statcan.gc.ca/en/start) or Nova Scotia Economics and Statistics (https://novascotia.ca/finance/statistics/) to characterize the angler community of respondents relative to the general population of the province.

For open-ended questions (e.g., reasons for fishing), an inductive qualitative thematic coding method was used. First, responses were read to identify keywords, which became a list of potential codes. Similar potential codes were then grouped into themes. Responses were read a second time and tagged with these themes to determine their prevalence. A response may have been associated with multiple themes if warranted. Coding was performed by the first author.

To quantify relationships between the reasons for fishing identified and various other demographic or behavioural characteristics, we developed a suite of Bayesian statistical models in PyMC (v4; www.pymc.io). Multiple reasons for fishing were often identified within a given response, leading to multinomial responses. As our objective was to summarize responses among groups, rather than pursue predictive modelling or causal inference, models were built for each covariate, using a Dirichlet multinomial data likelihood. Selected key covariates included 1) when a participant learned to fish (young/adult), 2) where a participant learned to fish (in Nova Scotia/elsewhere), 3) newcomer status (immigrant or refugee/born in Canada), 4) target species (target mackerel/other or no preference for target), 5) disability (disability identified/no disability identified), 6) fishing platform (wharf/beach

or shoreline/boat), and 8) social context (alone/friends/family/kids). Models were evaluated for convergence using traceplots and R-hat statistics (McElreath, 2020), and full model code and outputs are available online (https://gist.github.com/mamacneil/69680dd42be3c4174ae6f9759d7b6919).

Results

Demographics of survey respondents

There were 285 total responses received, with 215 (75.4%) fully completed surveys. About half of respondents (n=115, 51.6%) live in HRM, which is similar to, but may slightly overrepresent, the proportion of Nova Scotians who reside in HRM (48%)[6]. The next most numerous counties included nearby Lunenburg County on the south shore of Nova Scotia (n=22, 9.9%) and Cape Breton Regional Municipality (n=15, 6.7%), the largest community on Cape Breton Island, although rural Queens, Shelburne, Yarmouth, Annapolis, Kings, Hants, Colchester, Cumberland, Pictou, Antigonish, Guysborough, Richmond, Inverness, and Victoria counties were all represented (Figure 2). These results are largely consistent with the counties in which anglers said they fished, suggesting that while there is some intra-provincial travel to fishing spots (notably anglers from HRM leaving the urban setting to fish in more rural counties), most people tend to fish relatively close to where they live. A relatively large number of respondents (n=25, 11.4%) identified as newcomers to Canada (i.e., immigrants or refugees; nearly double the 6.1% of the provincial population comprising immigrants[7]). Furthermore, 14 respondents (5.9%) identified as Indigenous (on par with 5.7% of the provincial population that identifies as Indigenous[8]), suggesting that some people with Indigenous rights to fish (i.e., *via* FSC fishing) self-identify as recreational anglers. While the vast majority (n=186, 83.8%) of respondents were native English speakers, there were numerous French-speaking anglers (n=27), perhaps representing the province's long-standing Acadian population, in addition to smaller groups of speakers representing dozens of other languages.

With respect to gender identity, those who responded suggest that the fishing community is a largely male-dominated group, with 182 (82%) identifying as male. Additionally, 48 (24%) identified as having a disability, which was a slightly lower proportion than the provincial prevalence of 30%[9]. Physical (i.e., mobility, flexibility, pain) challenges were the most common disabilities identified by respondents. Only 3 of these individuals were off work due to their disability, while the others were either working or retired. Education levels were largely consistent with the general population of Nova Scotia[10], with 44 (19.7%) respondents identifying a high school diploma as the highest level achieved (versus 25.3% of the provincial population, the largest education category) and 44 (19.3%) respondents identifying a community college diploma (21.8% of the general population). Completion of an apprenticeship was slightly more prevalent among respondents (n=33, 14.8%) than the general population (9.9%), whereas the prevalence of having attained a university Bachelor's degree (n=36, 16.1%) was slightly below provincial metrics (20.8%), despite the fact that local university publication channels were one of the various methods used to promote the survey. The most common annual household income within the group was the $25 000-50 000 (CAD) band (n=49, 22.2%), which was below the median household income in NS (median income in 2020: $66 300, excluding zeros, for "economic families and persons not in economic families, per Statistics Canada[11]). The majority of respondents (n=121, 54.5%) were employed full-time, with a substantial secondary group of retired individuals (n=44, 19.8%). There were 18 respondents (8.2%) who identified as working (or having worked) in the commercial fishery sector.

Benefits from fishing

In asking why respondents fish recreationally for Atlantic mackerel, eight key themes emerged (ordered from highest to lowest probability of an angler choosing the reason): 1) food, 2) sport, 3) bait, 4) social connection, 5) time outdoors, 6) accessibility, 7) relaxation/mental health, and 8) tradition (Table 1). We found that fishing for food, sport, and bait were the most likely reasons to fish for mackerel (Table 1). Most respondents cited the taste and nutritional value (e.g., omega-3 fatty acids) of the fish as key reasons they eat mackerel as food. Our respondents also explained that this fishing activity may contribute to their own food security (e.g., "Mackerel is a vital resource for our family, we try to stock up some to help get us

6 https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/hlt-fst/pd-pl/Comprehensive.cfm

7 https://www12.statcan.gc.ca/census-recensement/2016/as-sa/fogs-spg/Facts-pr-eng.cfm?LANG=Eng&GK=PR&GC=12&TOPIC=7

8 https://www12.statcan.gc.ca/census-recensement/2016/as-sa/fogs-spg/Facts-PR-Eng.cfm?TOPIC=9&LANG=Eng&GK=PR&GC=12

9 https://novascotia.ca/accessibility/prevalence/

10 https://novascotia.ca/finance/statistics/news.asp?id=13362#:~:text=sex%20cohorts%20and-,HIGHEST%20LEVEL%20OF%20EDUCATION,Scotians%20reported%20a%20college%20diploma.

11 https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1110019101&pickMembers%5B0%5D=1.5&cubeTimeFrame.startYear=2016&cubeTimeFrame.endYear=2020&referencePeriods=20160101%2C20200101

TABLE 1 Prevalence of motivations for anglers fish for Atlantic mackerel or Amalamaq (*Scomber scombrus*) in Nova Scotia/Mi'kma'ki for recreational purposes.

	Mean	SD	HPD 3%	HPD 97%
Food	0.443	0.024	0.399	0.490
Sport	0.216	0.021	0.178	0.257
Bait	0.173	0.019	0.138	0.209
Social	0.065	0.013	0.041	0.089
Outdoors	0.036	0.009	0.020	0.055
Accessibility	0.033	0.009	0.018	0.051
Relaxation	0.023	0.008	0.010	0.038
Tradition	0.010	0.005	0.002	0.020

Values are posterior means and standard deviations (SD), with lower (HPD 3%) and upper (HPD %97) 94% uncertainty intervals, given by the highest posterior density (HPD) from an intercept-only Bayesian model.

through the winter"), provide food for pets (e.g., domestic cats), or be shared with friends, family, and especially elders in their community who enjoy eating mackerel. However, most identified that there was limited impact on their grocery budget or that the expenditures on gas and equipment negated any financial benefit of the value of the food. Individuals who fished for sport found the activity "fun", "challenging", "engaging", or found the 'thrill of the chase' satisfying (e.g., "I love the feeling of catching 3-4 on the line it's a great fight…"). Among anglers who aim to acquire bait to use in other fishing activities, most cited recreational striped bass (*Morone saxatilis*) fishing as the use of the bait, although others mentioned targeting sharks, groundfish (e.g., Atlantic cod), and one respondent even used it in bear hunting, with the bear meat harvested serving as subsistence food for them.

Social connection was the next most likely reason for fishing, with respondents citing the great camaraderie that takes place while mackerel fishing, "bonding with friends and family", and the opportunity to meet people from different backgrounds, ages, and cultures. The motivation to get outdoors was another key benefit, i.e., "the enjoyment of being in nature" or "something to do while enjoying the sea". Accessibility of the fish and fishing activity was another reason respondents choose mackerel fishing, citing that they "are relatively easy to catch compared to other fish", require little gear, and are "youth friendly" (i.e., appropriate for teaching children to fish). Relaxation or mental health was identified as an additional reason for fishing (e.g., "It is a wonderful peaceful way of relaxing, love the solitude with nature."). Tradition was a theme that emerged from comments identifying mackerel fishing as a regular seasonal activity they anticipate, an activity they learned from their family growing up (e.g., "…it is an outdoor activity that I have enjoyed since I was a child. I was raised in a fishing family."), or as an activity to pass on to youth in their community. Crucially, most respondents identified multiple reasons for, and benefits derived from, recreational mackerel fishing.

Covariates of fishing benefits

Modeling reasons for fishing as a function of when a respondent learned to fish revealed that those who grew up fishing from a young age were much more likely to fish for food (2.8x, Bayesian highest posterior density [HPD] odds ratio) or bait (2.2x) than an angler who learned to fish as an adult (Figure 3). On the other hand, anglers who learned to fish as adults were more motivated by relaxation (2.8x), tradition (1.7x), and accessibility (3.5x). Anglers who learned to fish in Nova Scotia were more likely to fish for food and bait than those who learned to fish elsewhere. In contrast, folks who learned to fish elsewhere were much more likely to be motivated by tradition (2.1x) and accessibility of the fishery (3.1x). Modelling results suggest newcomers (i.e., immigrants or refugees) to Canada were more likely to fish mackerel for accessibility (2.2x), sport (1.9x), and food (1.5x) than Canadian-born anglers. In contrast, Canadian-born anglers were more likely to fish for social connection, relaxation, or bait.

Model results suggest that anglers targeting mackerel specifically were more likely to fish for sport (1.6x), food (1.4x), and social (1.3x) reasons than those with less target specificity. Those with less preference for catching mackerel specifically were more likely to be motivated by tradition (2.6x), accessibility (1.9x) or bait (1.6x). In addition to Atlantic mackerel, anglers most frequently caught pollock (n=99 responses), striped bass (n=69 responses), cod (n=57 responses), squid (n=55 responses), and flounder (n=44 responses; Table 2). It should be noted that it appears some of these species are caught incidentally or concurrently while Atlantic mackerel fishing (e.g., pollock, squid), while others are likely caught during separate recreational fishing trips (e.g., striped bass; suggested by the differences in species distribution and gear types required), but it was not always possible to conclusively distinguish between the two scenarios.

Anglers who identified as having a disability were much more likely to fish for food (2.1x) than others, whereas, perhaps

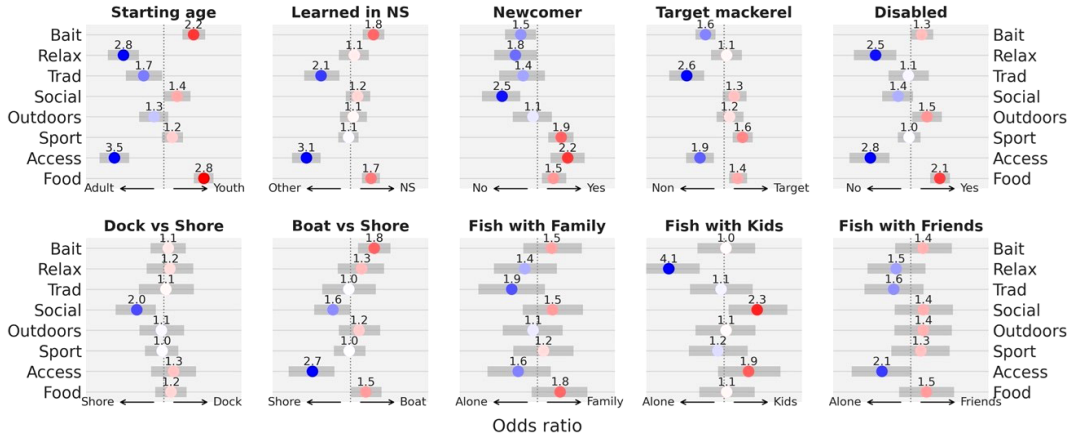

FIGURE 3
Odds ratio plots for reasons anglers fish for Atlantic mackerel or Amalamaq (*Scomber scombrus*) in Nova Scotia/Mi'kma'ki for recreational purposes as a function of selected key covariates. Points are highest posterior density (HPD) odds ratios for conditions listed at the bottom of each panel, with grey bars representing 50% HPD intervals. Grey bars not spanning unity (vertical 1:1) are considered to have clear evidence of differences between groups. Colours shaded for magnitude of the odds ratio for conditions on the left (blue) and right (red).

surprisingly, those who did not identify as having a disability cited relaxation (2.5x) and fishery accessibility (2.8x) more often. Considering fishing platforms, those fishing from a wharf/dock and beach/shore had relatively high interest in fishery accessibility compared to those fishing from a boat. Anglers fishing from a beach/shore were more likely to cite social connection as a reason for fishing (e.g., 2x more than wharf/dock). Modelling reasons for fishing as a function of social context suggests that those fishing alone are more motivated by tradition and accessibility than those fishing with friends or family. Anglers fishing with children are much more likely to be interested in the value of social connection (2.3x) and accessibility of the fishery (1.9x), but they are much less likely to fish for relaxation.

There was no evidence of a relationship between reasons for fishing and avidity (frequency of fishing trips). Anglers of various income levels fished for similar reasons, with increased income associated with a slightly higher likelihood to be motivated by food and slightly smaller likelihood for fishing as a tradition. While men and women both fished for similar reasons, model results suggest that women were much less likely to fish for mackerel to use as bait than their male counterparts.

TABLE 2 Additional species of fishes caught by recreational Atlantic mackerel fishers in Nova Scotia/Mi'kma'ki.

Common name	Species name	Number of mentions
Pollock	*Pollachius virens*	99
Striped bass	*Morone saxatilis*	69
Cod	*Gadus morhua*	57
Squid (Shortfin)	*Illex illecebrosus*	55
Flounder (Various, e.g., Yellowtail, Winter)	*Various (e.g., Pseudopleuronectes americanus, Limanda ferruginea*	44
Cunner/Perch	*Tautogolabrus adspersus*	41
Sculpin	*Myoxocephalus* spp.	40
Herring	*Clupea harengus*	24
Trout (Various, e.g., Speckled/brook, brown, lake, rainbow)	*e.g., Salvelinus fontinalis, Salmo trutta, Salvelinus namaycush, Oncorhynchus mykiss*	13
Haddock	*Melanogrammus aeglefinus*	13
Eel	*Anguilla rostrata*	10
Smelt	*Osmerus mordax*	9
Other	Various	140

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Management and conservation

About half of respondents identified that they catch fewer Atlantic mackerel now than in the past (n=122, 48.8%) and most reported that they are smaller than they used to be (n=148, 59%). Notes shared by survey respondents suggest that this might vary among sites (not specified), at different times of the year, and that there were sometimes trade-offs between number and size (i.e., they might see more fish, but fewer of legal size to retain). It is likely that individuals who selected "Not sure" for these questions did not have a long enough time series to compare, as the majority in this category had been fishing <1 year or 1-3 years. Virtually all respondents have observed fishing regulations for Atlantic mackerel getting stricter over time.

While the purpose of the questionnaire was not to identify support for or alternatives to current management practices, many opinions on conservation and management were shared in the open-ended comments, suggesting an interest in engaging with management procedures (Figure 4). The group was split in supporting current regulations (n=22 comments), opposing current regulations (n=21 comments), and advocating for changes to regulations (n=20 comments). A total of 35 comments across these categories highlighted concerns over the impact of commercial fisheries or explicitly blamed the commercial fishery for declines in the mackerel stock. Assessing relative impacts of these fisheries is beyond the scope of the present research.

Those in favour of the regulations expressed desire for a sustainable fishery, sometimes citing concerns about other depleted fish populations in Atlantic Canada, including herring and various groundfish, such as Atlantic cod. They believe stricter rules in response to fewer and smaller fish made sense, acknowledging that all anglers "have a role to play" in ensuring future stock health. Many cited concerns about the large amount of catch (sometimes caught for the commercial bait fishery under the guise of recreational fishing, particularly before there was a bag limit instated), illegal retention of undersized fish, and unethical handling/discard methods that they had observed from other recreational anglers. One respondent drew a comparison with hunting and described surprise at the lack of education, enforcement, and licencing in recreational fishing compared to the rigorous protocols in place to ensure sustainable harvest of land animals in the region. Another individual mentioned interest in a saltwater licence that would apply to recreational species including mackerel. However, importantly, it was made clear that in any case, these regulations must be developed and implemented in cooperation with the fishing community and informed by the local knowledge of anglers to ensure that they are based upon credible, legitimate, and salient information. As one respondent put it, "We're out here fishing and understand the species and therefore it would be beneficial to listen to us."

On the other hand, respondents who opposed current regulations largely felt that the restrictions were disproportionate to the small perceived impact that recreational anglers have on the resource, particularly in comparison to the more intensive commercial fishery. A sentiment shared by numerous respondents was that "recreational fishers are being penalized for

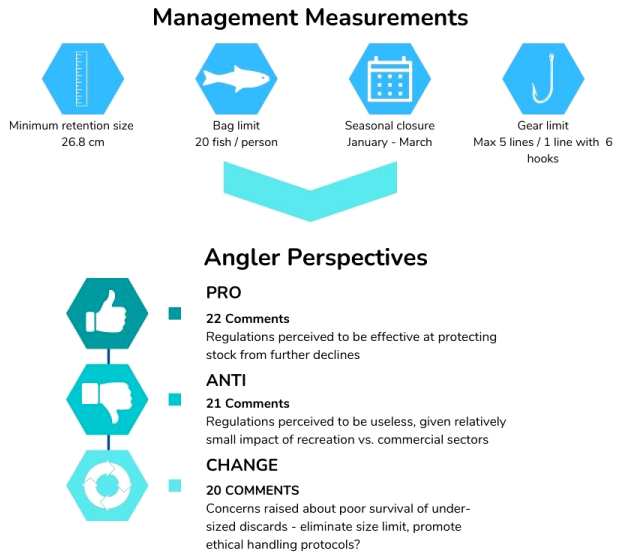

FIGURE 4
Summary of current restrictions and angler perspectives on current management measures (2021-2022) for recreational Atlantic mackerel or Amalamaq (*Scomber scombrus*) fishing in Nova Scotia/Mi'kma'ki.

commercial overfishing". The impact of purse seiners was specifically cited as an example of a commercial fishery capable of making detrimental impacts on the stock. There were concerns that management efforts might jeopardize important food-gathering activities of locals. Some expressed dismay that a fish so well-suited to human consumption (e.g., because of taste/nutrition) was commonly used as a bait fish. In any case, most anglers felt that it is important that this fishery resource remains a public good ("the people's fish"), rather than a species only accessible for commercial purposes

Advocates for regulation changes unanimously highlighted concern over post-release survival of undersized discarded fish, given that "current regulations mean that often undersized fish are thrown back even after they are seriously injured by the hooks". It is believed by many respondents that mackerel has a high vulnerability to handling stress relative to other species. Given that there is a minimum size limit, a 20-fish/person bag limit, and overall fewer big fish to be caught, the result may be forced high-grading and a much higher rate of mortality of mackerel than the bag limit would suggest. Some anglers propose doing away with the size limit and allowing the first 20 fish caught (of any size) to be retained to reduce waste. Alternatively, gear modification (e.g., hook type) and ethical handling practices were suggested to improve survival of discards.

Additional insights from open-ended comments included concerns about climate change (e.g., impacts on timing to migration), access to preferred fishing spots (e.g., overcrowding at popular wharfs, addition of 'no fishing' signs in certain locales, accessibility for anglers with disabilities), food safety (e.g., possible signs of contamination in fish from heavily industrialized Halifax Harbour), and continuity of Indigenous traditions (i.e., connection between declines in wildlife populations and loss of Mi'kmaq culture). With respect to Indigenous traditions, one participant elaborated that they are one of the few left in their reservation community who still practices traditional Mi'kmaw culture, including mackerel fishing. They cite environmental challenges such as global warming and social challenges such as prevalence of social media as key barriers to the continuity of traditional Mi'kmaw ways of life.

Other participants felt that mackerel fishing is an activity that binds Nova Scotians together, with one participant describing it as a shared cultural activity uniting and benefiting African Nova Scotians, Mi'kmaq, Acadians, and newcomers to the province. Another respondent even suggested it could be an untapped opportunity for ecotourism. In particular, fishing was highlighted as a means of engaging youth in ocean stewardship (e.g., through activities such as the Little Fishers Club, Bedford, NS; https://www.facebook.com/groups/382070278528023). Additionally, a number of anglers expressed interest in future research on another local, understudied recreational species, often targeted by mackerel anglers: shortfin squid (*Illex illecebrosus*).

Discussion

Benefits from fishing

If fisheries are valuable for benefits beyond economic gain, it is important to engage with the full range of rightsholders and stakeholders utilising the resource to understand who they are, and how and why they fish, in order to make management decisions in consideration of continued access to the full range of benefits derived from fishing. Here we identified numerous important motivations for, and benefits derived from, recreational mackerel fishing in Nova Scotia, including the recreation value and aesthetic aspects of getting outside in nature (i.e., cultural ecosystem services) highlighted from other studies (UNEP, 2006; Hunt et al., 2013), in addition to the provisioning of nutritious, culturally appropriate food. These benefits contribute to numerous social objectives for fisheries, such as those outlined by the Canadian Fisheries Research Network (Stephenson et al., 2019), namely the objectives of health and well-being (e.g., *via* the physical and mental health benefits of relaxation, time outdoors, and nutritious food) and sustainable communities (e.g., *via* local, accessible food, social connection, and tradition).

Fishing for mackerel for consumption was the most-cited reason to fish in our study. Thus, Atlantic mackerel represents a relatively rare example of a fish stock harvested in eastern Canada and largely consumed locally (as opposed to exported to high-value markets; Fisheries and Oceans Canada, 2022) and prepared at home (as opposed to consumed in a restaurant). An analogous fishery in the region could be the recreational fishery (sometimes known locally as the "food fishery") for Atlantic cod, most notably within the neighbouring waters of the province of Newfoundland and Labrador, another stock (famously) under commercial moratorium. While Arlinghaus and Cooke (2008) discuss recreational fisheries as "non-commercial fishing activities that are not the individual's primary resource to meet nutritional needs", this definition may underplay the various ways food plays a role in coastal communities. For example, while mackerel might not be necessary for food security in the region [defined as "physical and economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 2003)], it might play a significant role in food sovereignty, a concept which encapsulates "the right of local peoples to control their own food systems, including markets, ecological resources, food cultures, and production modes" (Wittman, 2011). There might be alternative protein sources available for many, but Atlantic mackerel fishing is a form of small-scale fishery that provides culturally appropriate and nutritious seafood for a wide range of communities across the region, with a relatively high degree of accessibility, insofar as limited equipment or expertise is required to catch mackerel during high-density 'runs' in the summer and autumn months.

However, the desire to harvest food synergizes with other social and cultural motivations and benefits. The activity of fishing for mackerel also contributes significantly to cultural heritage in the region, for Indigenous communities who have harvested mackerel in the region for millennia (Denny et al., 2020), for those in non-Indigenous communities in Nova Scotia with centuries of experience mackerel fishing (Fisheries and Oceans Canada, 1982), and for newcomers arriving in Nova Scotia from around the country and around the world, bringing their traditions of catching and consuming fish with them, as evidenced by this study. Recreational mackerel fishing is an intergenerational activity, in terms of sharing food with community elders, bonding with family members, and teaching children about the marine environment and food harvest.

Access to fishing

Our findings highlight that accessibility is also a significant motivation to take part in this fishery for those who learned to fish as adults (and perhaps have less fishing skills and experience), newcomers to Canada (who may have less knowledge about local species, fishing locations, and practices), and those fishing with children (who seek a 'starter' fish to teach children angling techniques). Individuals fishing with children appear to be focused on the youth experience, prioritizing the social connection, as opposed to their own relaxation. Anglers with disabilities were less likely to say they fished mackerel because it was easily accessible, perhaps because they face additional barriers, or perhaps because this group already consists of experienced anglers who need not seek out an 'easy catch'. Our findings suggest that public availability of dock and wharf infrastructure, as well as appropriate stretches of shoreline (ideally with a deeper 'drop-off'), are associated with fishery accessibility. Beach and shoreline locations appear particularly important for social connection, perhaps because there is more space to congregate and they offer alternative activities for other friends and family members.

While the diversity of the angler community creates rich opportunities for multicultural and intergenerational relationship-building at the wharf and on the water, this means that there are also several complex priorities to balance in managing fishery access moving forward. This includes access for rural coastal communities, access for urban anglers in the face of coastal gentrification and industrial development[12], and access for newcomers to Canada. Recreational fishing effort in and near urban centres (such as HRM) is particularly understudied (McPhee, 2017; Kadfak and Oskarsson, 2020; Griffin et al., 2021). However, social processes such as demographic change and urbanization, including those occurring recently in the rapidly growing HRM[13], are known to affect recreational fishing participation (Bissell et al., 1998), so it is essential to consider these mechanisms in visioning a future for this fishery.

Interestingly, we found that those with less preference for mackerel as a target species were more interested in tradition, accessibility, and bait than those with target specificity. This highlights that for many, the activity of fishing itself is as important as what is caught. Awareness of these non-catch benefits of recreational fishing is important, particularly for a stock in decline. When satisfaction with fishing experience is decoupled from catch, high levels of effort may be maintained despite declines in fish abundance (Hyder et al., 2020; Kleivan et al., 2020; Nieman and Solomon, 2021). On the other hand, anglers can continue to enjoy some of the benefits of fishing as a sport even if retention of fish is limited.

Management and conservation implications

The value of recreational angler experiential knowledge, such as the information documented here, is greater than ever before as of the upcoming 2022 fishing season in light of the recent commercial fishery closure. Many of the respondents to our survey noticed declines in fish abundance and size over time, and thus this community might represent a pool of potential local resource stewards who could help enact win-win solutions for people and the environment (Granek et al., 2008), perhaps analogous to partnerships between Ducks Unlimited and hunters (Reid et al., 2002). As demonstrated here, anglers find management measures more acceptable when they reflect their knowledge base and address the most urgent perceived threats to the fishery (Granek et al., 2008; Zukowski et al., 2011; Hyder et al., 2020). Granek et al. (2008) identified enforcement, advocacy, conservation, and research as key venues through which recreational anglers could directly engage with management.

Indeed, in this study, some important insights were captured incidentally with implications for fisheries management efforts. First, it appears that recent increases in recreational restrictions on Atlantic mackerel have largely been imposed to reduce large-scale fishing (e.g., for commercial bait) under the guise of 'recreational' fishing (Van Beveren et al., 2017a). Respondents' perceptions that recreational catch may be less of a management concern than harvest for commercial reasons seem correct, although accurate measures of catch from recreational

12 https://www150.statcan.gc.ca/n1/daily-quotidien/220209/g-b001-eng.htm

13 https://www150.statcan.gc.ca/n1/daily-quotidien/220209/g-b001-eng.htm?utm_source=citynews%20halifax&utm_campaign=citynews%20halifax%3A%20outbound&utm_medium=referral

mackerel fishing remain unknown (Brushett et al., 2019; Van Beveren et al., 2017b). This was reflected in the 2022 government decision to close commercial and bait fisheries, while maintaining FSC and recreational access (Government of Canada, 2022). Furthermore, current restrictions on the fishing season implemented during the winter months do not appear to limit true recreational fishing activity in practice, given that recreational fishing largely takes place in summer and autumn. While a saltwater licence, brought up by one respondent, has been discussed as an option within the DFO advisory process in the past, it has yet to be implemented, perhaps due to lack of support from stakeholders or lack of prioritization by internal decision-makers. Given the numerous comments contributed here opposing increasing restrictions, it is unclear whether recreational mackerel anglers would be supportive of licensing. Additional comments about the influence of climate change on mackerel abundance or distribution are also important, as these issues are of interest to fisheries scientists and fisheries managers as well (Overholtz et al., 2011; Bruge et al., 2016; McManus et al., 2018; Mbaye et al., 2020). In fact, there are numerous calls to action (Boyce et al., 2021) and work is underway (Pepin et al., 2022) to better integrate climate and other oceanographic considerations into fisheries assessments in Canada.

Many community concerns shared in open-ended comments centred on post-release mortality of undersized fish. While it may be controversial to advocate for the removal of a minimum size limit for a fish stock in decline, given long-standing inclusion of size limits for conservation purposes in a wide range of fisheries, this regulation ignores the particular sensitivity of mackerel to handling stress observed by many of the respondents (see also Tenningen et al., 2021). Instead, relying primarily on the bag limit to restrict catch might actually lead to reduced mackerel mortality in the recreational fishery. Although in freshwater fisheries, long dominated by recreational users, catching fish of a certain size is optimized as opposed to maximizing yield (Ihde et al., 2011), it is well known that there are a variety of species, particularly in the marine environment, for which catch-and-release measures are ineffective for a variety of reasons [e.g., Atlantic cod (Ferter et al., 2015) or rockfish (Granek et al., 2008) barometric effects, admittedly less of a concern for a fish like mackerel which lacks a swim bladder]. Alternatively, or additionally, community-led education efforts around gear recommendations and ethical guidelines for handling fish could minimize handling stress and improve survival of undersized discarded fish. It is essential that restrictions are effective and appreciated by the community, given that effective data collection and management rely on an engaged fishing community that understands and wants to support management (Cooke et al., 2019; Hyder et al., 2020).

A key challenge for rebuilding the Atlantic mackerel stock is the use of mackerel for bait in large commercial fisheries. It appears that bait usage in recreational fishing also has a (likely much smaller) impact on the mackerel stock as well. A shift from conventional use of bait fish to the development of alternative bait products has been proposed as a conservation solution in the commercial sector (Hewitt, 2018; Patanasatienkul et al., 2020; Zhou, 2021). Recreational anglers may also benefit from alternative bait options in the pursuit of species such as striped bass, which could shift recreational fishing pressure on mackerel to prioritize access for those fishing for food/nutritional or cultural purposes. Given that we found evidence of more interest in bait among individuals with less target species specificity, it appears that mackerel bycatch or species able to be caught concurrently with mackerel might be acceptable bait equivalents for recreational anglers. It is essential that, in any case, recreational fishers are engaged directly to help inform or test the efficacy and acceptability of bait alternatives.

Methodological reflections

It is important to acknowledge that due to the opt-in nature of the questionnaire used in this study, "historical legacies and contemporary realities" introduce bias with respect to who would choose to respond, which would in turn influence results documented here (Biggs et al., 2021). For example, given that language barriers were sometimes encountered during community outreach, and given the relatively high proportion of immigrants and refugees identified in the survey, it is likely that respondents from this group represent a subset of a larger, more diverse community of newcomer anglers. While multilingual outreach materials were developed, it was not possible to administer and analyze the questionnaire itself in multiple languages, and additional sociocultural factors may have influenced willingness to share personal information. Also, while FSC fishing was not the focus of this study, our work demonstrates that at least some FSC mackerel fishers harvest alongside other anglers. A recent study of the Mi'kmaw mackerel fishery has been explored through a Mi'kmaw Ecological Knowledge workshop conducted by Unama'ki Institute of Natural Resources (Denny et al., 2020), and is worthy of separate consideration by management officials in light of differential rights to fishery access held by Indigenous groups in the region.

Furthermore, there is a history of mistrust among fish harvesters, scientists, and fisheries managers in eastern Canada which can be traced back decades to the Atlantic cod stock collapse and moratorium in the 1990s (Hutchings et al., 1997; Neis et al., 1999; Murray et al., 2006; Haggan et al., 2007; Murray et al., 2008; Hutchings, 2022). Willingness for some anglers to participate in fisheries research may have been impacted by personal experience with, or media exposure to, these issues. In addition, there was likely a bias toward engagement with urban anglers given that the research team was based in HRM and was able to conduct more regular dockside visits in the (sub)urban

area. Having the questionnaire available online increased reach province-wide, but potential respondents without reliable internet access, or those who have less comfort or interest in use of technology, may have been underrepresented because of our reliance on a virtual survey platform. Despite these limitations, there is qualitative evidence of information saturation in most response categories, and thus the insights presented here are still of great value. Although cultural traditions might be similar in other parts of eastern Canada where Atlantic mackerel is caught for recreational purposes, it is unclear the extent to which it is appropriate to extrapolate our findings to other provinces beyond Nova Scotia.

Conclusion

For Atlantic mackerel in Canadian waters, there remain important knowledge gaps in understanding of biological processes, relatively short and few survey inputs, and under-reporting of catch from both domestic and bordering international fisheries (e.g., overlap with the Southern contingent of Atlantic mackerel in neighbouring American waters) (Van Beveren et al., 2017b). These must be addressed if successful rebuilding of the stock for ecosystem health, continued FSC/recreational access, and a reopening of commercial/bait access, is to be realized. At the same time, it is important that in developing conservation strategies, particularly in light of scientific uncertainty, these efforts do not unintentionally cause social harms which might undermine local stewardship capacity and support for stock recovery (Bennett et al., 2021). For example, here we document a range of benefits relating to both food provisioning and cultural ecosystem services currently enjoyed by the large community of recreational mackerel anglers in Nova Scotia, which might be threatened threatened either by continued decline of the stock, or regulations which may limit access to the fish.

In order to make management decisions informed by this complexity, more holistic fisheries assessments are necessary, which will likely require greater input from a larger and more diverse group of rightsholders and stakeholders (e.g., for recreational fishing: Cooke and Cowx, 2006; Granek et al., 2008; Mapstone et al., 2008). For example, here we demonstrate that recreational mackerel anglers from a variety of rural, suburban, and urban communities must be engaged, and that resources to facilitate the inclusion of both Indigenous fishers and newcomer anglers must be available. By speaking directly to members of the fishing community, as we have done in our study, fisheries scientists and managers can avoid traps such as reinventing the wheel when knowledge is already held by the fishing community; making incorrect assumptions about human behaviour; dismissing human components of the system as too complex; or distilling human influence to an inappropriately simplistic assessment of 'impact' (Hunt et al., 2013). Assessing the wide range of different ways people rely on and interact with fish is an essential first step toward healthier human-nature relationships, thriving ocean ecosystems, and sustainable and equitable provisioning of benefits for fish harvesters of all stripes.

Data availability statement

The datasets presented in this article are not readily available because Ethics approval was subject to the dataset being kept confidential and saved securely by the research team. However, all results and Python code used for analysis are publicly available, as noted in the manuscript (https://gist.github.com/mamacneil/69680dd42be3c4174ae6f9759d7b6919). Requests to access the datasets should be directed to kayla.hamelin@Dal.ca.

Ethics statement

The studies involving human participants were reviewed and approved by Dalhousie University Research Ethics Board (2021-5622). The patients/participants provided their written informed consent to participate in this study.

Author contributions

KH led the conceptualization, methodology, investigation, formal analysis, writing (original draft), visualization, and project administration. MM was involved in methodology, formal analysis, writing (review and editing), visualization, and funding acquisition. KC contributed to conceptualization, investigation, and writing (review and editing). MB was involved in conceptualization, methodology, writing (review and editing), supervision, and funding acquisition. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary Material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2022.971262/full#supplementary-material

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