

RESEARCH ARTICLE

The overlooked role of food and cultural dimensions in recreational fisheries

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Abstract Our study examines the diversity of values within a superficially homogeneous recreational fishery and its relationship to angler diversity. We collected data on fishing preferences, behaviors, catch usage, and sociodemographics from 443 shore anglers across 10 cities in the lower Great Lakes. We identified five coherent dimensions, including food, cultural, leisure, challenge/performance, and social–financial centrality, consistent with multidimensional value structuring in recreational fisheries. Based on these patterns, anglers were classified into three data-driven groups along a food provisioning–leisure/sport continuum: provisioning/food-oriented, cultural/community-oriented, and leisure/sport-oriented. We further characterized these groups by differences in their fishing preferences and sociodemographics. These findings provide empirical support that recreational and non-recreational values coexist and jointly characterize angler diversity in urban shore fisheries. Our study highlights the need for future research and management to treat food provisioning and cultural practices as core dimensions of recreational fisheries that reflect anglers’ diverse values and needs.

Keywords Angler diversity · Cultural practices · Food provisioning · Great Lakes · Multidimensional values · Urban recreational fisheries

INTRODUCTION

Recreational fisheries are conventionally thought of as leisure or sport activities. Although it has long been acknowledged that anglers¹ pursue multiple benefits (Cooke et al. 2018; Nyboer et al. 2022), recreational fisheries continue to be predominantly operationalized within leisure- and sport-centered traditions. This orientation can obscure the extent to which non-recreational values, such as food provisioning, identity, and cultural practices, shape participation of many anglers (Nguyen et al. 2025). The diversity of values and fishing practices has been a key focus of inquiry in recreational fisheries literature (Hunt et al. 2023; Nguyen et al. 2025). With an estimated 220 million people participating worldwide (World Bank 2012; Arlinghaus et al. 2014), anglers represent a wide range of social, cultural, and economic backgrounds. As the participation of people from diverse backgrounds increases in many regions (American Sportfishing Association 2025), the values, preferences, and behaviors associated with fishing are also expected to diversify in ways that remain poorly understood (Méthot et al. 2015; Arlinghaus et al. 2020). Examining how these diverse values are studied within mainstream analytical frameworks is therefore important to advance a more nuanced conceptualization of recreational fisheries across regions and governance contexts.

Recreational fisheries research has typically examined angler diversity using established frameworks such as fishing motivations, catch orientation, and centrality to

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¹ We use the term “angler” for simplicity to refer to fishers with recreational fishing licenses, recognizing that licensed fishing may involve a range of legal gear types (e.g., rod and reel, hand lines, small traps) depending on jurisdiction.

lifestyle (Driver and Knopf 1976; Fedler and Ditton 1986; Scott and Shafer 2001). While these frameworks have been foundational, they were primarily conceived and operationalized participation through leisure- and sport-specific constructs. Although food provisioning and cultural meanings are sporadically acknowledged in the literature (see Nguyen et al. 2025 for a review), they have rarely been systematically incorporated across these frameworks within a single empirical design. As a result, their role as potential structuring dimensions of angler diversity remains insufficiently evaluated. This gap motivated us to take a closer look at how these frameworks have been operationalized in recreational fisheries research and how they might be extended to reflect the diversity of values shaping contemporary recreational fisheries. In the following sections, we briefly unpack each framework and explain how food provisioning and cultural practices may extend their application in contemporary recreational fisheries.

Fishing motivation, defined as the experience anglers expect to achieve through fishing, is a central framework to understand angler diversity (Driver and Knopf 1976; Fedler and Ditton 1994; Manfredi et al. 1996). However, this framework has largely focused on leisure and sport pursuits (Manfredi et al. 1996), with limited attention to food-oriented motivations. In recreational fisheries, motivations are typically categorized as either activity-general or activity-specific. Activity-general motivations are common to many recreational pursuits, such as enjoying nature, spending time with family and friends, or relaxation (Moeller and Engelken 1972; Driver and Knopf 1976; Fedler and Ditton 1994). Activity-specific motivations are unique to fishing and include the thrill of catching fish, improving fishing skills, and pursuing trophies or large fish (Fedler and Ditton 1986; Finn and Loomis 2001; Beardmore et al. 2011). However, food-oriented motivations have rarely been included in this categorization, despite evidence from the 1990s that anglers consume their catch (Ebert et al. 1993; Connelly et al. 1996) and more recent evidence that food provisioning is an important driver of participation for many anglers (Embke et al. 2020; Quimby et al. 2020; Venker et al. 2025). Some studies also found disproportionate exposure to consumption-related risks among specific sociodemographic groups, underscoring the cultural and dietary importance of fish consumption within some angling communities (Hutchison and Kraft 1994; Burger et al. 2001; Burger 2002; West et al. 2019). These studies demonstrate the significance of food-oriented motives and practices in recreational fisheries, yet this evidence has rarely been incorporated into a broader framework of fishing motivations, leaving a critical gap in understanding the full spectrum of angler diversity and fishing practices.

Catch orientation, including the related concept of consumptive orientation, has also been used as a framework to classify angler diversity (Aas and Kaltenborn 1995; Robinson and Rash 2023). In the recreational fisheries literature, catch orientation refers to an angler's attitude toward four catch-related aspects of fishing: (i) simply catching something, (ii) catching many fish (numbers), (iii) catching large fish, and (iv) retaining fish (Aas and Vittersø 2000; Anderson et al. 2007; Hunt et al. 2007; Hutt et al. 2013; Schroeder and Fulton 2013). Studies using this framework have recognized that anglers assign varying degrees of importance to different catch outcomes, including harvesting practices. However, harvesting fish is not equivalent to food provisioning as a broader social practice. Existing catch orientation measures alone provide limited insight into how harvested fish are used and whether fish consumption is connected to household food needs, sharing practices, cultural identity, or intergenerational traditions. In addition, the catch-related attitudinal diversity complements the motivation framework, particularly when motivational measures include food-oriented motives. For example, anglers motivated by consumption of self-caught fish must retain their catch, whereas anglers motivated by sport pursuits may prioritize the experience of catching large or trophy fish. In contrast, anglers motivated by relaxation or enjoyment of the outdoors may assign little emphasis on any specific catch outcomes. However, when motivations and catch orientation are examined in isolation, latent structure in angler diversity may remain obscured, especially in fisheries where anglers with a wide range of motives participate. Incorporation of motivation and catch orientation frameworks therefore has strong potential to explain cross-cutting patterns and characterize angler diversity.

Centrality to lifestyle, a key subcomponent of angler specialization, has been widely used in recreational fisheries to characterize anglers (Bryan 1977; Scott and Shafer 2001; Oh and Ditton 2006). It captures the importance of fishing in a person's lifestyle relative to other leisure activities (Sutton and Ditton 2001) or their psychological commitment to fishing (Scott and Shafer 2001). However, items used to measure centrality to lifestyle have largely relied on activity-general indicators and treated fishing primarily as a leisure pursuit (Dorow and Arlinghaus 2012; Beardmore et al. 2013; Sutton and Oh 2015; Birdsong et al. 2022, 2025; Slaton et al. 2023), despite evidence that self-caught fish is important to many anglers' livelihoods and well-being (Beehler et al. 2002; Burger 2013). Many of those items were adapted from leisure research outside fisheries, such as birdwatching (Kim et al. 1997), even though fishing can involve cultural identity, food provisioning, community life, and place attachment (Hutchison and Kraft 1994; Dickinson et al. 2015; Serenari and

Peterson 2021; Venker et al. 2025). A more multifaceted measure of centrality could therefore incorporate these non-recreational dimensions alongside traditional leisure-based indicators. To our knowledge, these values and associated benefits have rarely been incorporated into the centrality to lifestyle framework.

There is growing recognition of the need to broaden attention to the diverse values, practices, and meanings associated with fishing (Nguyen et al. 2025). Beyond direct food and nutritional benefits (Ebbin 2017; Embke et al. 2022; Nyboer et al. 2022; Lynch et al. 2024), anglers have been found to use harvested fish to offset food costs, supplement household incomes, achieve food sovereignty (i.e., having the ability not just to access food but to produce it), and sustain intergenerational traditions, knowledge, and sociocultural practices (Steinback et al. 2009; Liu et al. 2019; Nieman et al. 2021; Hamelin et al. 2022; Venker et al. 2025). Apart from the coupled food-cultural benefits, for many individuals, recreational fisheries are integral to their sense of identity and connection to place (Khakzad and Griffith 2016; Landon et al. 2018). However, most studies examining non-recreational values of fishing have been case-based, descriptive, or limited to documenting these values within specific social groups, such as Indigenous peoples or particular ethnic and racial communities. As a result, current recreational fisheries literature often implies that non-recreational values are (i) peripheral to the conceptualization of recreational fisheries and (ii) primarily associated with particular social groups rather than being recognized across the broader angler population.

Our study builds on the contributions of Cooke et al. (2018) and Nyboer et al. (2022), who used case studies across multiple regions to demonstrate the prevalence of anglers using recreational fishing licenses to secure food and nutritional provisions. Nguyen et al. (2025) followed up by reviewing and consolidating findings from a wide body of literature to emphasize the importance of different non-recreational values within recreational fisheries. They proposed a framework that explicitly combines both recreational and non-recreational values as core elements of recreational fisheries, highlighting the multidimensional nature of recreational fishing in general. In this study, we extend this line of inquiry and operationalize the proposed multidimensional perspective by explicitly incorporating food and cultural dimensions into established frameworks of motivations and centrality to lifestyle. In doing so, we conceptually and empirically evaluate whether these dimensions are merely supplementary attributes or instead part of the latent structure that organizes angler diversity in recreational fisheries. In addition, given the environmental and socioeconomic significance of recreational fisheries (Arlinghaus and Cooke 2009; Arlinghaus et al. 2019),

understanding the diverse values that may structure angler diversity is essential to inform management strategies that can be responsive to different forms of participation and fishing practices. In line with that, we ask three questions:

- (i) To what extent do recreational and non-recreational values differ among anglers, indicating a multidimensional recreational fishery?
- (ii) How can we operationalize a multidimensional perspective within the established frameworks (i.e., motivations, catch orientation, and centrality to lifestyle) to study angler diversity?
- (iii) What distinct angler groups emerge from employing a multidimensional perspective, and how do angler groups differ in relation to their attitudes and sociodemographics?

MATERIALS AND METHODS

Study areas

Our study areas consisted of 10 cities across Lakes Erie and Ontario of the Laurentian Great Lakes Basin: Detroit, Toledo, Cleveland, Buffalo, and Rochester in the USA; and Windsor, St. Catharines, Hamilton, Toronto, and Kingston in Canada (Fig. 1). We purposively selected these cities to capture a heterogeneous, urban angler population with respect to demographic diversity. Within these cities, we intercepted shore anglers at 48 popular fishing sites selected based on observable shoreline access and local confirmation that sites are regularly fished. We allocated the number of survey sites per city based on log-transformed population metrics (i.e., population density and household counts). This approach prevented disproportionately high sampling effort in larger cities while maintaining representation across the study region. Site selection and sampling protocols were informed by participant observation and key informant interviews with fisheries managers, conservation officers, and local tackle and bait shop staff to ensure relevance and local contexts.

Survey instrument

Our survey instrument was comprised of four broad sections: (i) fishing behaviors, (ii) fishing preferences, (iii) consumption behaviors, and (iv) sociodemographic factors (Appendix S1: Supplementary Questionnaires).

To assess fishing behaviors, we asked questions about fishing experience, season-specific data on fishing effort, catch composition, harvest behaviors, and total catch in a typical fishing day during spring, summer, and fall.

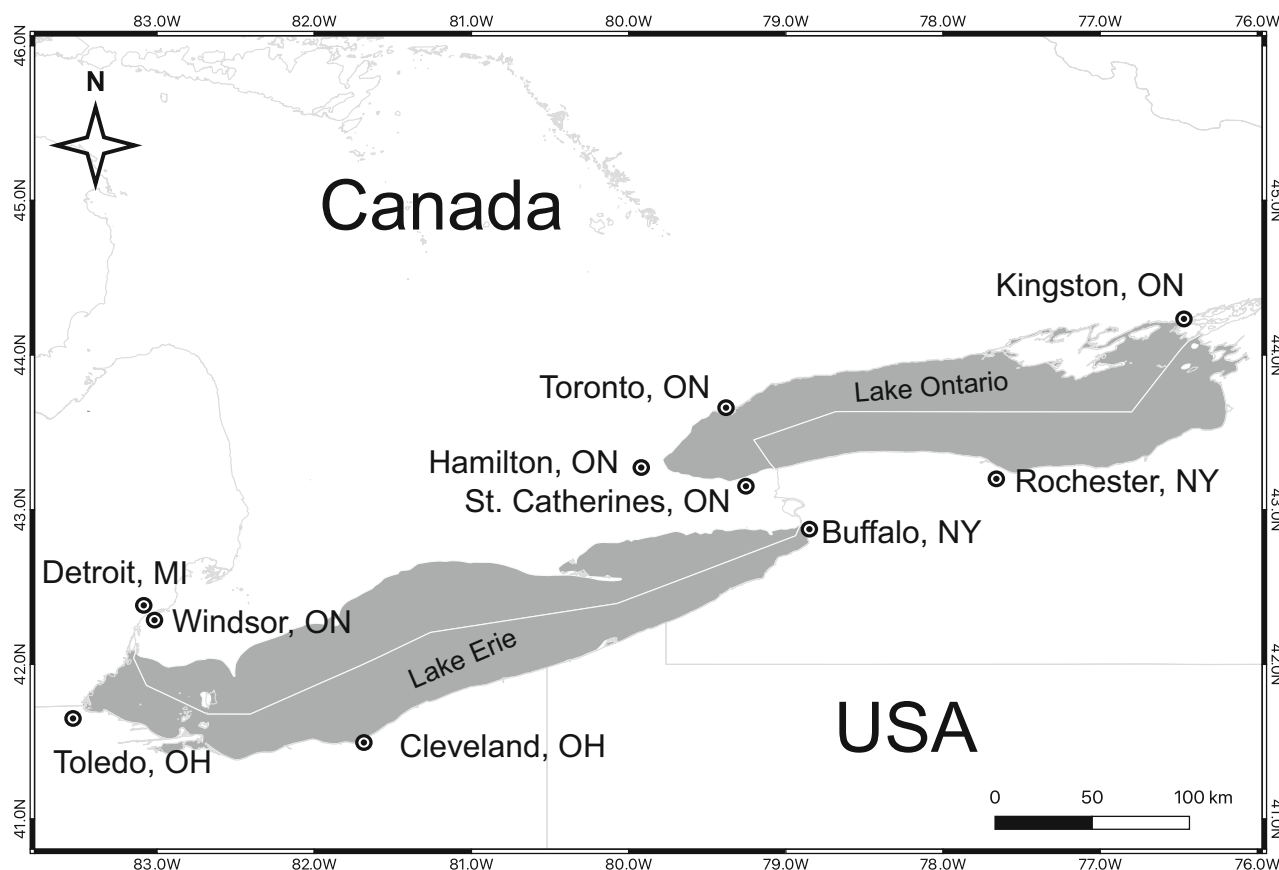


Fig. 1 Map of Lake Erie and Lake Ontario showing 10 major shoreline cities where angler surveys were conducted

To assess fishing preferences, we used 21 items rated on a 5-point Likert-type scale to measure fishing motivations (Fedler and Ditton 1994; Manfredo et al. 1996), catch orientation (Sutton and Ditton 2001; Anderson et al. 2007; Schroeder and Fulton 2013; Robinson and Rash 2023), and centrality to lifestyle (Dorow and Arlinghaus 2012; Beardmore et al. 2013; Birdsong et al. 2022; Slaton et al. 2023; Birdsong et al. 2025). Questions from these frameworks were adapted to represent both recreational and non-recreational values including leisure, sport, food, livelihood, and cultural aspects. Under fishing motivations, we added new items that can be used to understand underlying motivations related to food and cultural practices. We treated centrality to lifestyle as a multifaceted construct capable of reflecting economic, cultural, and social embeddedness. These modifications were essential to operationalize and empirically test the multidimensional nature of recreational fisheries. Based on the evidence that many anglers not only harvest fish for themselves but also share with fellow anglers or their neighbors (Burger 2013; Ebbin 2017; Hamelin et al. 2022), we also collected data to understand different types of catch usage among anglers

and used it alongside other frameworks. All items are presented in Table 1.

To assess fish consumption behaviors, we measured anglers' fish-eating frequency, reliance on locally caught fish, commonly consumed self-caught species, and awareness and use of fish consumption advisories.

For sociodemographics, we included questions to collect data about anglers' age, gender, ethnicity, household income, education level, employment status, and languages spoken at home.

We first piloted the survey instrument with members of the research team and then tested with 12 anglers based in Buffalo, New York. After incorporating the feedback, we digitized the revised questionnaire using Qualtrics software. Our research received ethical clearances from the Carleton University Research Ethics Board B (Project #28729) and Virginia Tech Institutional Review Board (Protocol #22-462).

Data collection and processing

We collected a total of 482 survey responses from shore anglers using intercept and online recruitment strategies. Intercept surveys were conducted by trained local research

Table 1 Items used to assess angler preferences (i.e., fishing motivations, catch orientation, and centrality to lifestyle) and catch usage

Items under different frameworks	Abbreviated form
Fishing motivations	
<i>I fish to spend time with my family/friends.</i>	<i>motive: socialize</i>
<i>I fish for the sport or excitement or thrill of catching fish.</i>	<i>motive: sport</i>
<i>I fish to eat fish as food for myself and/or my family.*</i>	<i>motive: food</i>
<i>I fish because it's part of my culture and traditions.*</i>	<i>motive: culture</i>
<i>I fish because I enjoy being outdoors or close to nature.</i>	<i>motive: outdoor</i>
<i>I fish because it connects me to my past and childhood memories.</i>	<i>motive: memory</i>
<i>I fish to relax (helps to reduce my anxiety/stress/depression).</i>	<i>motive: relax</i>
<i>I fish to work on my fishing skills.</i>	<i>motive: skill</i>
Catch orientation	
<i>The more fish I catch, the happier I am.</i>	<i>catch: more fish</i>
<i>I need to keep the fish I catch for the trip to be successful.</i>	<i>catch: keep fish</i>
<i>The bigger fish I catch, the better the fishing trip.</i>	<i>catch: big fish</i>
<i>When I go fishing, I'm happy even if I don't catch fish.</i>	<i>catch: no fish</i>
Centrality to lifestyle*	
<i>If I stopped fishing, I would lose my friends.</i>	<i>ctl: lose friend</i>
<i>If I stopped fishing, I would lose my traditions and/or culture.</i>	<i>ctl: lose tradition</i>
<i>If I stopped fishing, I would lose an important source of protein.</i>	<i>ctl: less protein</i>
<i>If I stopped fishing, I would not have fish to eat.</i>	<i>ctl: less food</i>
<i>If I stopped fishing, I would lose a source of income.</i>	<i>ctl: less income</i>
<i>Fishing helps relieve some financial stress.</i>	<i>ctl: financial relief</i>
Catch usage*	
<i>I use fish as food (for myself/family/for later use).</i>	<i>use: as food</i>
<i>I use fish to save money on food.</i>	<i>use: save money</i>
<i>I share fish with my friends, or neighbors, or relatives for free.</i>	<i>use: share fish</i>

Asterisks (*) indicate items or frameworks that were newly developed or adapted for this study

assistants using a stratified spatiotemporal sampling approach, with greater sampling effort on weekends and holidays to reflect higher fishing activity. We used online recruitment to broaden geographic and seasonal coverage through QR-code follow-up from intercept contacts (those who preferred to complete the survey later), tackle-shop distribution, Facebook groups, and an email listserv. After applying quality-screening criteria, we retained 443 responses for analysis (253 from intercept and 190 from online surveys). The full recruitment, screening, and sample-retention process is summarized in Fig. 2 (Panel A) and described in the Appendix S2: Supplementary Methods.

Before data analyses, we also evaluated survey-mode effects (intercept vs. online) on items representing fishing motivations, catch orientation, centrality to lifestyle, catch usage, as well as anglers' sociodemographic factors. A detailed justification for pooling intercept and online survey responses can be found in the Appendix S2: Supplementary Methods (Tables S3 and S4).

Data analyses

We analyzed the data using a stepwise workflow designed to identify and characterize distinct angler groups. First, we described sample characteristics. Second, we examined the multidimensional structure of items related to fishing motivations, catch orientation, centrality to lifestyle, and catch usage among anglers. Then, we used cluster analysis and multiple validation criteria to determine the number of distinct angler groups. Fourth, we used canonical discriminant analysis to define and interpret group separation. Finally, we characterized the resulting groups in relation to attitudinal-behavioral profiles and sociodemographic variability. The full analytical workflow is summarized in Fig. 2 (Panel B), with detailed statistical procedures in the Appendix S2: Supplementary Methods.

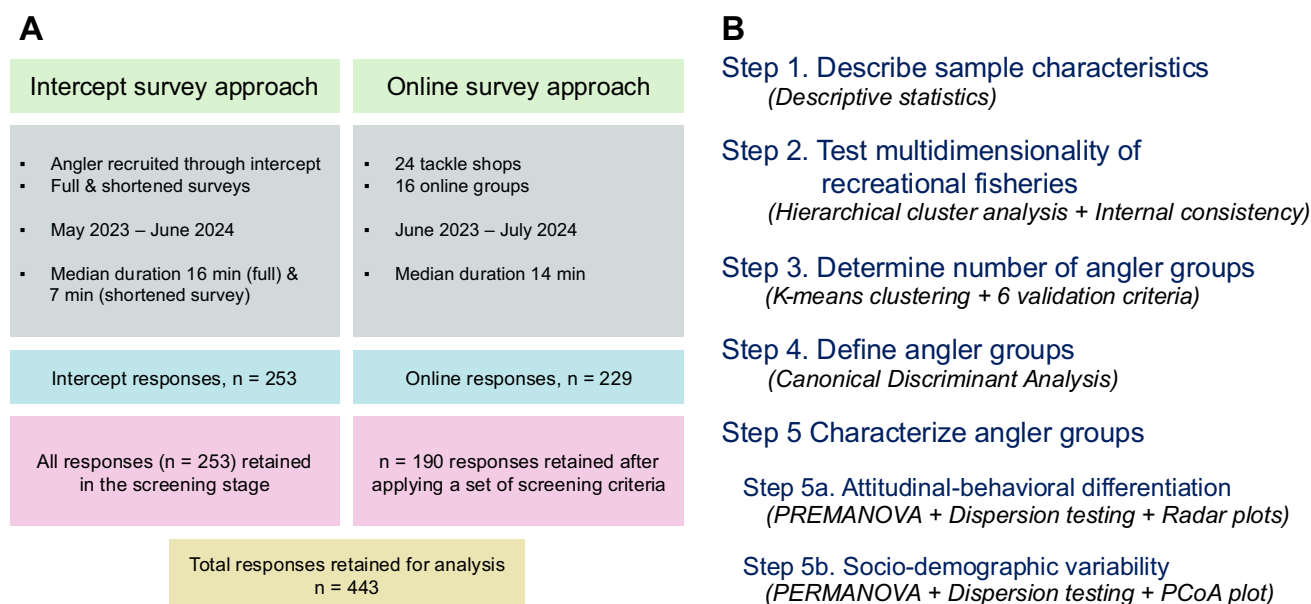


Fig. 2 Overview of data collection, screening, and analytical workflow. Panel A summarizes the intercept and online survey recruitment pathways, screening process, and final retained sample. Panel B summarizes the stepwise analytical workflow

RESULTS

Description of participant anglers

Anglers who participated in our study represented a heterogeneous sample spanning a broad range of sociodemographic and economic conditions, fishing intensity, and harvest orientations (Table 2). They represented a wide age distribution (44 ± 15) and were predominantly male, with substantial variation in ethnicity, education, income, and employment status. We reported ethnicity as White and Non-white; however, the Non-white category includes respondents who self-identified as Arabic, Black, East Asian, Latino, Native American, South Asian, Southeast Asian, or mixed race. Around one-third of anglers (32.3%) reported speaking at least one language other than English. The most frequently reported non-English languages were Spanish (31.8% of non-English language mentions), Mandarin (11.0%), Arabic (7.1%), French (6.5%), and Bengali, Cantonese, and Portuguese (each 4.5%). Nearly three-quarters of anglers (74.6%) reported more than 5 years of fishing experience, whereas two-thirds (66%) reported their average fishing effort to be 3–6 h on a typical fishing day across seasons. Participant anglers also varied in their catch-retention practices and general fish consumption frequency (Table 2).

Multidimensionality in recreational fisheries

Results of hierarchical cluster analysis showed that recreational fisheries in the lower Great Lakes (i.e., Erie and

Ontario lakes) are inherently multidimensional. The items representing fishing motivations, catch orientation, centrality to lifestyle, and catch usage by anglers revealed five meaningful and conceptually interpretable latent dimensions that represent recreational and non-recreational dimensions of fisheries (Fig. 3). Items related to food-oriented values and behaviors (i.e., *motive: food*, *use: as food*, *use: share fish*, *catch: keep fish*, detailed description in Table 1) clustered together to form a coherent food provisioning dimension. Similarly, culturally related items (i.e., *motive: culture*, *ctl: lose tradition*) grouped together, indicating that cultural or traditional items tended to co-occur within the same cluster in this dataset. Sport- and skill-oriented motivations (i.e., *motive: sport*, *motive: skill*) clustered with indicators of catch quality and quantity (i.e., *catch: big fish*, *catch: many fish*), which was consistent with a challenge- or performance-oriented dimension. Items associated with relaxation and enjoying outdoors while fishing (i.e., *motive: outdoor*, *motive: relax*, *catch: no fish*) can be interpreted as leisure dimension, and rest of the items (i.e., *ctl: lose friend*, *ctl: lose income*, *ctl: financial relief*, and *use: save money*) clustered as a social–financial centrality dimension.

Analysis of internal consistency for each of these dimensions provided an empirical basis in support of the multidimensional nature of recreational fisheries in the lower Great Lakes. Both food provisioning and social–financial centrality dimensions were represented by item sets with high internal consistency ($\alpha \geq 0.85$). The cultural dimension demonstrated a moderate internal consistency ($\alpha = 0.71$), indicating a coherence that links fishing

Table 2 Sociodemographic and fishing characteristics of survey participants

Characteristics	Value
Age (years), mean (SD)	43.75 (15.04)
Gender	
<i>Male</i>	83.6%
<i>Female</i>	16.4%
Ethnicity	
<i>White</i>	53.6%
<i>Non-white</i>	46.4%
Education	
<i>High school or less</i>	28.7%
<i>More than high school</i>	71.3%
Household income	
< \$60 000 USD	46.3%
≥ \$60 000 USD	53.7%
Employment	
<i>Employed</i>	78.1%
<i>Not employed</i>	5.3%
<i>Retired or unable to work</i>	16.5%
Fishing experience (> 5 years)	74.6%
Average effort in a typical day	
<i>Low (< 3 hours day⁻¹)</i>	21.4%
<i>Medium (3–6 hours day⁻¹)</i>	66%
<i>High (> 6 hours day⁻¹)</i>	12.6%
Harvest behaviors	
<i>Release-all</i>	48.4%
<i>Selective keeper</i>	30.3%
<i>Keep-all</i>	21.2%
Fish consumption frequency	
<i>Never or rarely</i>	19.6%
<i>Monthly (1 to 3 times per month)</i>	36.8%
<i>Weekly (Once a week)</i>	25.2%
<i>Twice or more per week</i>	18.4%

% calculated among respondents with valid responses for each characteristic

practices to identity and tradition. However, leisure- and challenge-oriented dimensions showed moderate internal consistency ($\alpha \approx 0.57$ – 0.65), which rather showcased the conceptual breadth and non-redundant experiential components of items under these dimensions.

Identifying distinct angler groups

We found that urban anglers in the lower Great Lakes can be best represented by three distinct groups that reflect distinct values and orientations toward fishing. The k-means clustering and elbow method initially revealed that anglers could be grouped into either three or four clusters (Fig. S1). However, after examining both solutions

through six validation criteria, we found that the three-cluster solution provided a more interpretable and statistically robust partition of respondents, with a more parsimonious grouping of anglers (Fig. 4 and Table 3).

Defining angler groups in recreational fisheries

Findings from the CDA revealed that three clusters can be defined as provisioning/food-oriented, cultural/community-oriented, and leisure/sport-oriented angler groups. These groups reflect multidimensional values within recreational fisheries that structure angler diversity in the lower Great Lakes. The discriminant analysis separated the three groups along two orthogonal axes. The horizontal axis, Canonical Function 1 or Can1, explained 84.3% of the among-group variation and formed the primary discriminating axis. This axis distinguished leisure or sport aspects of fishing from food or subsistence practices (Fig. 5). The variables with the largest contributions to Can1 illustrated the divide between these two contrasting aspects of recreational fishing that primarily guided the characterization of three angler groups (Fig. 6). Canonical Function 2 or Can2 explained only 15.7% of the among-group variation and contributed comparatively less to angler group characterization. However, we used the separation along both axes as a conceptual basis to define three angler groups.

The blue cluster, occupied by the positive Can1 region (Fig. 5), was interpreted as leisure/sport-oriented anglers. These anglers emphasized outdoor enjoyment, sport, challenge, social companionship, and different catch-related goals such as catching large or many fish. However, anglers representing this group were positioned away from harvest-dependent dimensions of fishing. The two remaining groups were both located on the negative side of Can1, indicating stronger association with food-, harvest-, and culture-related dimensions than the leisure/sport-oriented group. However, they differed along Can2.

The red cluster, located higher on Can2, was distinguished as cultural/community-oriented anglers. Members of this group indicated higher agreement that stopping fishing would reduce income, reduce access to food or protein, affect traditions, and lead to the loss of social connections. For this group, fishing was closely tied to household well-being and continuity of tradition.

The green cluster, positioned between the two other clusters on Can1 and lower on Can2, was defined as provisioning/food-oriented angler group. This group was associated with direct food-use and provisioning practices, including using catch as food, sharing fish, food-oriented motivation, cultural motivation, and fishing-related memories. Provisioning/food-oriented anglers appeared less driven by food and economic dependence on fishing, whereas cultural/community-oriented group was

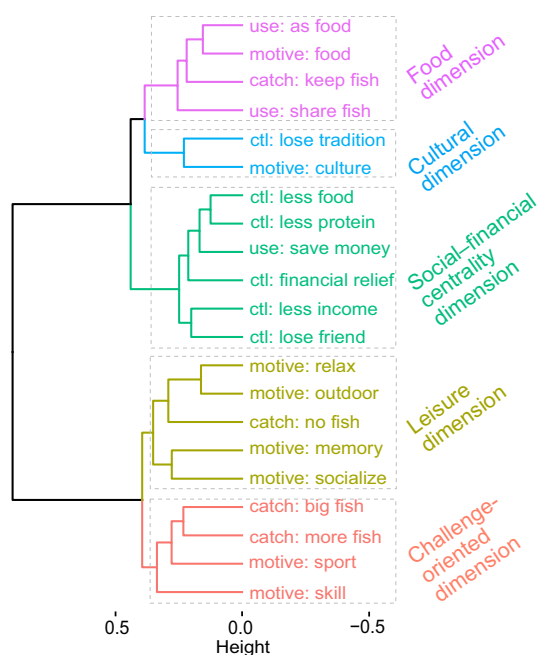


Fig. 3 Hierarchical cluster analysis of variables representing fishing motivations, catch orientation, centrality to lifestyle, and catch usage. Cutting the dendrogram at $k = 5$ yielded interpretable, theory-consistent dimensions: food, cultural/traditional, challenge-oriented, leisure, and social-financial centrality. The structure confirms that recreational fisheries are multidimensional in nature. The detailed description of abbreviated items is available in Table 1

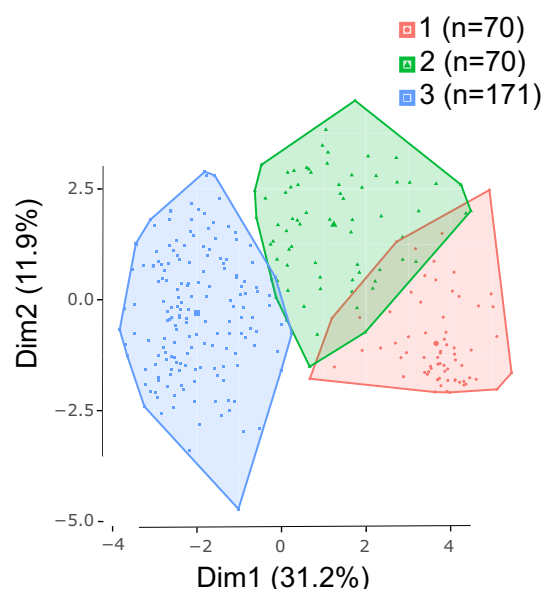


Fig. 4 Visualization of the three-cluster solution used to classify sampled anglers based on fishing motivations, catch orientation, centrality to lifestyle, and catch usage. Relative to the four-cluster solution, the three-cluster solution exhibited relatively clear separation and less overlap among clusters

characterized more by dependence, centrality, and consequences of losing fishing. CDA plot without the centrality to lifestyle items further illustrated the dependency of cultural/community-oriented group on fishing (Fig. S2).

Although we used distinct label as shorthand to interpret relative positions of each angler group in the multivariate space, individual anglers may exhibit mixed profiles. The clusters or angler groups are best understood as relative positions along a food provisioning–leisure/sport continuum, a pattern that remained evident when the analysis was repeated separately for intercept and online participants (Fig. S3).

Characterization of angler groups

Attitudinal-behavioral differentiation

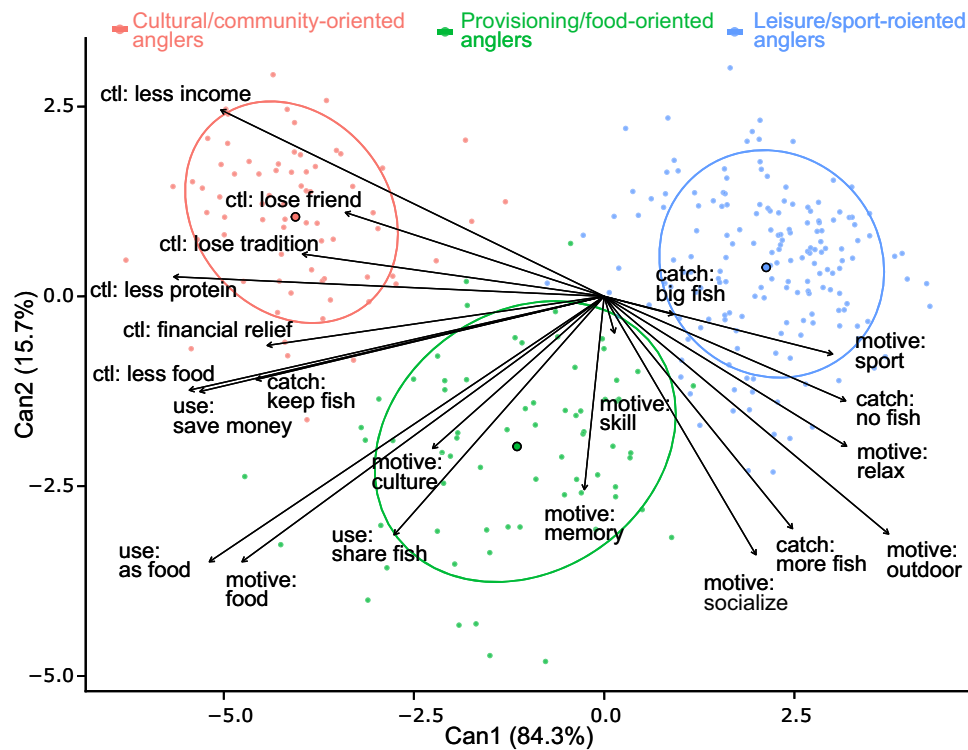
We found that angler groups in the lower Great Lakes differed most consistently (in explained variance terms) along items related to food provisioning practices, economic reliance, and social embeddedness. Our analyses revealed statistically significant differentiation among angler groups across all four frameworks (i.e., fishing motivations, catch orientation, centrality to lifestyle, and catch usage) examined in this study (PERMANOVA, $p < 0.001$). However, the magnitude of angler group differentiation varied substantially. Centrality to lifestyle and catch usage exhibited the largest multivariate separation among angler groups, explaining more than half of the total variation (centrality to lifestyle, $R^2 = 0.54$; catch usage, $R^2 = 0.55$). In contrast, fishing motivations and catch orientation showed a much lower differentiation ($R^2 \approx 0.28$ – 0.29) among angler groups.

After examining the within-group dispersion, we also found statistically significant differences for all four frameworks (permutation tests, all $p \leq 0.01$). These findings indicate that angler groups differed not only in their multivariate centroids but also in the degree of internal heterogeneity. However, dispersion effects were stronger for centrality to lifestyle and catch usage, consistent with greater variability in how fishing contributes to social, cultural, food provisioning, and economic well-being within angler groups (Figs. 7 and S4).

From radar plots, provisioning/food-oriented anglers consistently exhibited elevated scores for food-related motivations, fish use, and preference of keeping their catch, whereas leisure/sport-oriented anglers were characterized by higher sport and relaxation motivations and lower reliance on fishing for food or income. Cultural/community-oriented anglers showed the strongest centrality to lifestyle

Table 3 Comparison of validation statistics for the three-cluster ($k = 3$) and four-cluster ($k = 4$) k-means solutions. Most of the validation criteria supported a three-cluster solution

Validation criterion	$k = 3$	$k = 4$	Inference
Silhouette width	0.183	0.131	Clusters are more distinct in $k = 3$
Calinski–Harabasz index	72.28	59.68	Stronger separation & compactness in $K = 3$
Davies–Bouldin index	1.93	2.20	Lower within-to-between dispersion in $k = 3$
Mean uncertainty (GMM)	0.013	0.033	Lower classification ambiguity in $K = 3$
Ambiguous cases (< 70% prob)	0.3%	5.1%	Far fewer ambiguous cases in $k = 3$
Stability (mean ARI)	0.701	0.790	$k = 4$ is more stable under resampling

**Fig. 5** CDA biplot with three clusters. Canonical discriminant analysis of the three angler groups based on motivations, centrality to lifestyle, catch orientation, and catch usage. Arrows denote variable loadings (directions of increasing values). The canonical space separates groups largely along a food provisioning–leisure/sport gradient. Details of all the abbreviated items available in Table 1

profile, with consistently high perceived social, cultural, and economic consequences of fishing restrictions. However, across domains, the radar plots showcased similarity between provisioning and cultural anglers on food-related items. In consistent with multivariate tests, leisure/sport-oriented anglers remained distinct from the other angler groups. Item-wise statistical differences across three angler groups are presented in Table S5.

Sociodemographic variability

Angler groups identified in this study were not strongly separated by sociodemographic characteristics, despite

statistically detectable differences in multivariate composition. We found a statistically significant difference in multivariate sociodemographic composition among angler groups (PERMANOVA, $p = 0.013$). However, angler group membership explained only 2.2% of the multivariate variation in sociodemographic composition (PERMANOVA $R^2 = 0.022$), indicating that the magnitude of sociodemographic differentiation among groups was very small. We also found significant differences in within-group dispersion among angler groups (permutation test, $p < 0.001$) from the tests of homogeneity of multivariate dispersion. Both of these statistical findings indicated that observed sociodemographic differentiation may reflect

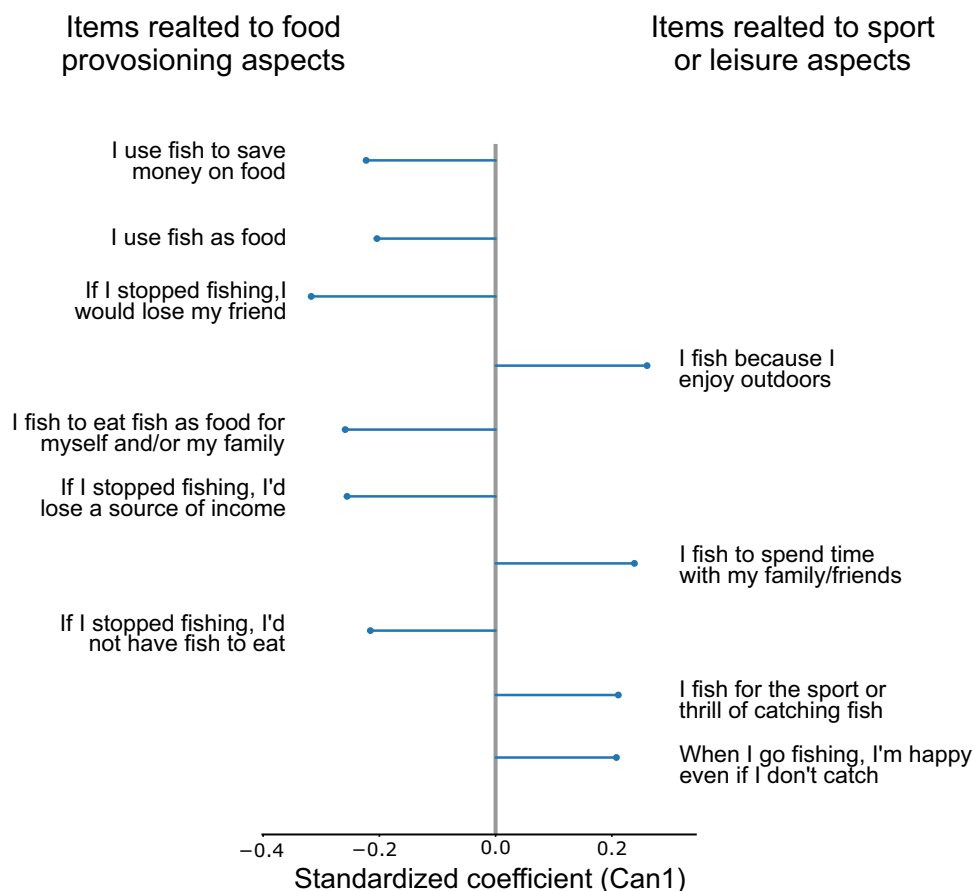


Fig. 6 The 10 largest variable contributions (by coefficient) to the first canonical discriminant function (Can1). The x-axis shows standardized coefficients; full item texts are shown on the y-axis. Positive coefficients align with leisure or sport and harvest-independent preferences, whereas negative coefficients align with reliance on fishing for food and harvest-dependent items

within-group dispersion or internal heterogeneity rather than distinct differences in group centroids alone. This interpretation was consistent with the principal coordinates analysis (PCoA), which showed substantial overlap among groups and differences in within-group spread (Fig. 8). Cultural/community-oriented anglers exhibited comparatively low dispersion, whereas provisioning/food-oriented and leisure/sport-oriented anglers showed greater sociodemographic heterogeneity (Fig. 8). Item-level tests of sociodemographic variables showed similar patterns, with mostly small or non-significant differences across groups (Table S6).

DISCUSSION

Our study provides empirical evidence that recreational fisheries are multidimensional, with recreational (leisure and sport) and non-recreational (food and cultural) values coexisting. The multidimensional nature of fisheries also explains the classification of angler groups in the lower

Great Lakes. Our analyses revealed that items related to food and cultural aspects of fishing consistently grouped together, distinguishing anglers oriented toward food provisioning from those oriented toward leisure and sport. Rather than fitting neatly into purely “sport” or purely “food subsistence” categories, many anglers exhibit mixed profiles along a dominant gradient from food provisioning orientation to leisure/sport orientation. These findings extend the long-standing leisure-sport framings of recreational fisheries rooted in recreation-experience traditions (Bryan 1977; Fedler and Ditton 1994; Beardmore et al. 2011) by showing that food provisioning and cultural dimensions, when measured alongside established constructs, can emerge as structuring elements of angler diversity. In addition, this empirical evidence supports recent calls to conceptualize recreational fisheries using a multidimensional perspective (Nguyen et al. 2025) where diverse values and associated benefits are integral for many participants. By documenting the co-occurrence of multiple values within individuals and across the fishery, our study suggests that a multidimensional perspective offers a more

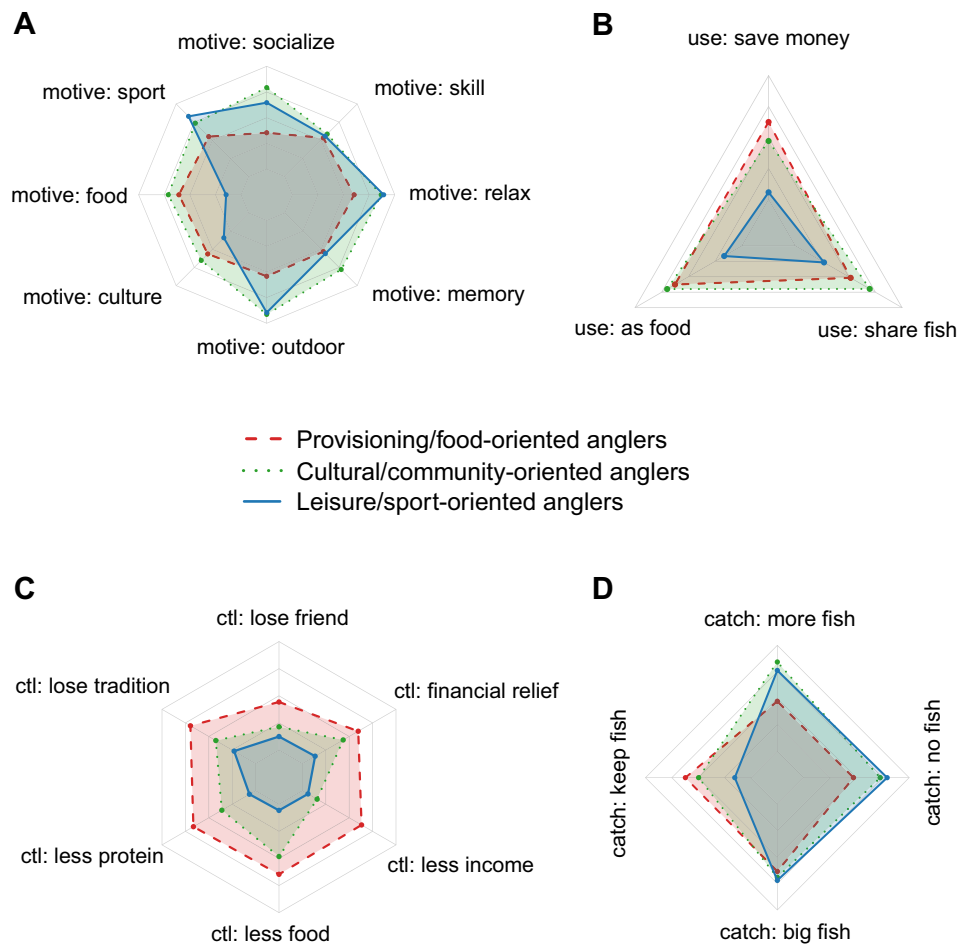


Fig. 7 Profiles of three angler segments across four attitudinal domains derived from cluster analysis. Radar plots depict cluster-level means (Likert 1–5) for **A** Fishing motivations (abbreviated as *motive*), **B** Catch usage (*use*), **C** Centrality to lifestyle (*ctl*), and **D** Catch orientation (*catch*). Lines denote the three angler segments identified: Provisioning/food-oriented (red, dashed), Cultural/community-oriented (green, dotted), and Leisure/sport-oriented (blue, solid). Larger radii indicate stronger agreement or importance. All panels share a common scale (with original ordinal scale) to facilitate comparison across domains

accurate account of how diverse values and associated benefits shape angler experiences in an urbanized, highly accessible system like the lower Great Lakes. More broadly, adopting a multidimensional perspective to the study of recreational fisheries provides a coherent foundation for improved measurement of different values to strengthen comparative inference and synthesis on angler diversity. While more studies are required to better understand the extent to which our findings are generic to other recreational fisheries contexts, we anticipate that the multidimensional perspective and analytical approach used in this study to be broadly transferable to other regions and governance contexts.

The presence of provisioning/food-oriented and cultural/community-oriented angler groups in our study reinforces the previous notion that recreational fishing can serve as an important source of food and cultural meaning for many anglers (Cooke et al. 2018; Nyboer et al. 2022).

More importantly, these groups emerged within a broad, sociodemographically heterogeneous, shore-based sample rather than being confined to specific ethnic or minority groups, as has sometimes been emphasized in prior studies (e.g., Nieman et al. 2021; Hamelin et al. 2022). This broader contribution recognizes the critical role that fishing can play in anglers' lives and livelihoods. It also suggests that food provisioning and culturally meaningful fishing practices are not limited to low-income, minority, or marginalized populations, but may represent a more mainstream and widely distributed dimension of participation in urban, shore-based fisheries in the lower Great Lakes. This interpretation aligns with wider evidence that inland recreational harvest can generate measurable nutritional benefits and economic value with growing recognition of a “fuzzy boundary” between recreational and subsistence practices in many inland fisheries (Nyboer et al. 2022; Nguyen et al. 2025).

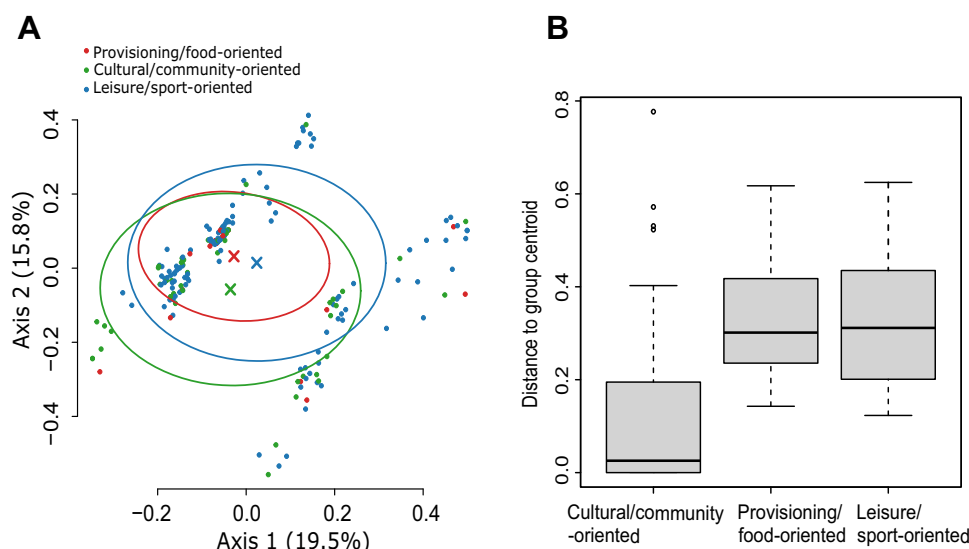


Fig. 8 Multivariate sociodemographic structure and within-group dispersion of angler groups. **A** Principal coordinate analysis (PCoA) of sociodemographic composition based on Gower distances, showing angler group centroids (crosses). **B** Within-group multivariate dispersion, expressed as distances of individuals to their respective group centroids. The panels illustrate modest separation in sociodemographic composition among angler groups alongside pronounced differences in internal sociodemographic variability

In this study, we demonstrate that operationalizing a multidimensional perspective on recreational fisheries benefited from revisiting and modifying items within the fishing motivations and centrality to lifestyle frameworks. Incorporating ‘fishing for food’ as a core element of motivation, alongside activity-general and activity-specific motives, improved the empirical characterization of diverse angler motivations in our dataset. In particular, it helped identify anglers who participate in fishing partly to satisfy a desire to consume self-caught fish. This modification may also strengthen the application of motivation framework across populations and regions where recreational fisheries contribute to food sustenance (Arlinghaus 2006; Nieman et al. 2021; Hamelin et al. 2022; Nyboer et al. 2022). We also found that centrality to lifestyle can function as a multifaceted construct indexing economic, cultural, and social embeddedness. Consistent with enduring involvement and specialization traditions (Bryan 1977; Oh and Ditton 2006), “centrality” reflects the extent to which an activity becomes integral to someone’s identity and lifestyle; however, our results suggest that this embeddedness can be expressed through distinct pathways, including material dependence (e.g., financial relief) and social/cultural continuity. In line with this argument, the centrality to lifestyle scale used in this study captured distinct pattern as subsistence-related items (i.e., *ctl: less food*, *ctl: less protein*, *ctl: financial relief*) primarily characterized cultural/community-oriented angler group. At the same time, the canonical separation is consistent with the interpretation that these forms of embeddedness are not merely correlates of motivation, but part of the dominant

structure differentiating anglers along the food provisioning–leisure/sport gradient. Though we largely focused on values related to food provisioning and cultural practices in the centrality of lifestyle items, incorporation of additional values (e.g., leisure, identity, stewardship) into this framework may provide further insight into angler diversity.

Despite introducing specific modifications on motivation and centrality to lifestyle frameworks, our analyses produced a coherent cross-framework signal, meaning food-linked items from motivation (i.e., *motive: food*), centrality to lifestyle (i.e., *ctl: less food*, *ctl: less protein*, *ctl: less income*), catch orientation (i.e., *catch: keep fish*), and catch usage (i.e., *use: as food*, *use: save money*) clustered tightly and loaded jointly on the food provisioning–leisure/sport axis. This cross-framework convergence supports the interpretation that food provisioning is not a single “special topic” item, but a latent construct that recreational fisheries researchers need to incorporate to study angler diversity. It also suggests to fisheries management that broadening the prevailing assumptions about what licensed anglers want and why they fish is crucial to recognize the full range of values and practices in contemporary recreational fisheries. It can also provide critical insights on the measurement validity and strengthen inference about when and to what extent distinct values, behaviors, and outcomes may co-occur across contexts.

Our findings on attitudinal–behavioral differentiation indicate that angler diversity is organized less by angler expectations (i.e., underlying motivations or catch preferences during fishing), but predominantly by what anglers

achieve through fishing or the functional roles fishing plays in everyday life. The stronger multivariate differentiation in centrality to lifestyle and catch usage (compared to weaker separation in motivations and catch orientation) suggests that social embeddedness, perceived livelihood consequences of fishing restriction, and food-related practices are prominent axes along which anglers diverge. This is consistent with long-standing evidence that anglers pursue diverse outcomes that are not fully captured by motivation measures alone (Fedler and Ditton 1994; Ward et al. 2016). The significant dispersion effects indicate that groups differ not only in their average profiles but also in how diverse they are within groups, especially for items linked to food provisioning, cultural meaning, and economic reliance. The partial overlap between provisioning/food-oriented and cultural/community-oriented anglers on food-related items, together with the clear separation of leisure/sport-oriented anglers, suggests that angler typologies in recreational fisheries may benefit from emphasizing how fish are used, the degree of dependence on fishing for food, and the sociocultural importance of fishing.

Our results indicate that anglers with similar sociodemographic profiles participate for different functional reasons and benefits. Three angler groups identified in this study could not be clearly distinguished in their sociodemographic composition, as shown by weak centroid separation and low variance explained. This finding reinforces the importance of attitudinal and behavioral measures as more fitting descriptors of angler diversity and suggests that meaningful heterogeneity may be overlooked if angler classification relies primarily on sociodemographic averages (Arlinghaus and Cooke 2009; Johnston et al. 2010). Moreover, the higher within-group heterogeneity among provisioning/food-oriented and leisure/sport-oriented groups indicates that these groups include broader sociodemographic constituencies, whereas the cultural/community-oriented group appears comparatively homogeneous. This within-group heterogeneity and diverse constituencies that make up specific angler groups can inform managers design more representative creel surveys, broaden engagement efforts, and develop more inclusive monitoring strategies to improve recreational fisheries management.

LIMITATIONS

Our sampling frame in this study focused on urban, shore-based access in Lakes Erie and Ontario, so angler diversity or overall pattern may differ in rural systems or mixed-access with boat-based fisheries (Arlinghaus et al. 2008; Golebie et al. 2020; Hunt 2024). Moreover, our data were cross-sectional and self-reported, which can be affected by recall and social-desirability biases (Tarrant et al. 1993;

Andrews et al. 2018; Lewin et al. 2021). While our centrality to lifestyle scale demonstrated satisfactory performance, we suggest further research to establish the factorial structure and evaluate measurement invariance using multi-group confirmatory factor analysis (CFA) to ensure that observed differences among angler groups reflect substantive variation rather than artifacts of differential scale functioning (Milfont and Fischer 2010). We also recognize that cluster solutions can be sensitive to data standardization, distance metrics, and initialization procedures (Jain 2010) as well as CDA relies on assumptions that, if violated, may affect the representation of group separation (Huberty and Olejnik 2006). However, we used CDA primarily for descriptive visualization of group separation rather than inferential classification. Finally, variation in research assistants' positionality, experience, and communication skill may influence intercept recruitment despite standardized training. In this study, our overall analytical approach emphasized characterization, providing a foundation for future studies to extend the application of multidimensional perspective on recreational fisheries toward more predictive and context-sensitive analyses.

CONCLUSION

Our study provides empirical evidence consistent with the interpretation that recreational fisheries in the lower Great Lakes are multidimensional: leisure, sport, food, and cultural aspects coexist and jointly structure angler diversity. The presence of three distinct angler groups, despite some overlap in their sociodemographic and behavioral characteristics, suggests that food provisioning and cultural practices are widespread, meaningful, and integral for many urban shore anglers. These results underscore the need for recreational fisheries research and management to move toward a multidimensional perspective that recognizes the diverse values, practices, and benefits associated with urban angling.

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Author contributions V.M.N., L.C., M.A.M., and M.K.B. contributed to the study conception and design. Material preparation and data collection were performed by all authors; data analysis was performed by M.K.B. The first draft of the manuscript was written by

M.K.B., and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

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