Canadian Journal of Fisheries and Aquatic Sciences

OPEN ACCESS | Research Article

Psychological commitment of freshwater anglers and its relation to their preferences for stocking and other management actions

Diana Perry[a], **Zachary A. Siders**[b], **Chelsey Crandall**[c], **Nia Morales**[d], **Robert Arlinghaus**[e,f], **Kai Lorenzen**[b], **and Edward Camp**[b]

[a]School of Natural Resources and Environment, University of Florida, Gainesville, FL, USA; [b]Fisheries and Aquatic Sciences, School of Forest, Fisheries, and Geomatic Sciences, University of Florida, Gainesville, FL, USA; [c]Florida Fish and Wildlife Conservation Commission, Tallahassee, FL, USA; [d]Wildlife Ecology and Conservation, University of Florida, Gainesville, FL, USA; [e]Division of Integrative Fisheries Management, Albrecht Daniel Thaer Institute, Faculty of Life Sciences, Humboldt-Universität zu Berlin, Berlin, Germany; [f]Department of Fish Biology, Fisheries and Aquaculture, Leibniz Institute of Freshwater Ecology and Inland Fisheries, Müggelseedamm 310, Berlin 12587, Germany

Corresponding author: **Diana Perry** (email: perryd@ufl.edu)

Abstract

Understanding stakeholder diversity can help natural resource managers tailor activities to achieve greater stakeholder satisfaction. Stakeholder diversity can be described by the concept of recreational specialization. Centrality-to-lifestyle, one subdimension of specialization that measures the psychological importance of a recreational activity to an angler, has been shown to explain many human dimensions and behaviors of recreational fishers and to correlate with preferences for management actions. We surveyed 9911 anglers in Florida, USA to examine how centrality-to-lifestyle relates to preferences for stocking and other management tools. We found that most anglers support stocking and that anglers of greater centrality-to-lifestyle had more positive views toward stocking than less central anglers. Participants, regardless of level of centrality-to-lifestyle, generally preferred stocking of one species, Florida largemouth bass (*Micropterus salmoides*), and they preferred habitat management above stocking, with no relation to centrality. The results suggest stocking can improve the satisfaction of anglers of all commitment levels, but habitat improvement could do so even more. Managers might consider prioritizing habitat management over stocking in systems where natural recruitment is ample to increase overall angler satisfaction, and where the anglers will, on average, support such actions independent of the degree of centrality.

Key words: stocking, centrality-to-lifestyle, satisfaction, recreational fisheries

Introduction

Understanding heterogeneity in angler management preferences improves the efficacy of governing freshwater recreational fisheries (Johnston et al. 2010; Beardmore et al. 2011; Potts et al. 2020; Gundelund et al. 2022; Hunt et al. 2023). Angler preferences are heterogeneous due to their different fishing experiences and expectations (Fisher 1997). For example, anglers vary in their desire to mainly target trophy-sized fish versus their desire for mainly high catch rates, to fish in wild vs. stock-enhanced fisheries, and whether they prefer stocking over habitat management and other tools to improve fisheries (Wilde and Ditton 1994; Fisher 1997; Wilde et al. 1998; Arlinghaus and Mehner 2005; Anderson et al. 2007; Johnston et al. 2010; Beardmore et al. 2015; van Poorten and Camp 2019; Koemle et al. 2021; Silwal et al. 2023). Management agencies frequently make management decisions based on the preferences of the "average" angler (Aas and Ditton 1998; Oh and Ditton 2006; Johnston et al. 2010), who usually prefers higher catch rates and larger fish (Beardmore et al. 2015; Arlinghaus et al. 2020; Birdsong et al. 2022). By managing for the "average" angler, managers may homogenize the fishing experience and inadvertently alienate anglers seeking other experiences, leading to angler dissatisfaction and possibly reduced participation or altered site choices (Hendee et al. 1974; Salz and Loomis 2005; Hutt and Bettoli 2007; Matsumura et al. 2019; van Poorten and Camp 2019). For recreational fisheries, managers need to consider how truly homogeneous their angling stakeholders are and address how management actions affect all angler types (Johnston et al. 2010), which increases the need for a greater understanding of the preferences of heterogenous anglers.

Angler preference heterogeneity has been historically described in terms of angler demographics (Ditton and Hunt 1996; Wilde et al. 1998; Hunt et al. 2012, 2023), residence (e.g., tourist and non-touristic anglers; Slaton et al. 2023), fishing modes (e.g., tournament vs. non-tournament anglers) (Wilde

et al. 1998) or motivations (Beardmore et al. 2011), but recreational specialization is perhaps the most frequently used framework to describe how anglers differ in a fundamental fashion (Bryan 1977; Chipman and Helfrich 1988; Fisher 1997; Ditton et al. 2002; Hunt et al. 2023). While easier to measure, demographics have not well explained differences in angler preferences (Arlinghaus and Mehner 2005; Hunt et al. 2012), although exceptions exist (Slaton et al. 2023). More commonly, research differentiated anglers by fishing motivations (Fedler and Ditton 1994; Wilde et al. 1998; Beardmore et al. 2011; Schroeder et al. 2018) or attitudes to catch (Fedler and Ditton 1986; Arlinghaus 2006; Kyle et al. 2007*b*). Using motivations to categorize anglers has been shown to be very context-dependent because they can change for individual anglers based on fishing mode and target species, among other reasons (Fedler and Ditton 1994; Wilde and Ditton 1994; Wilde et al. 1998; Beardmore et al. 2011), and general fishing motives have been shown to have relatively low explanatory power to explain more specific angler behaviors, such as site choices or release vs. retention decisions (Schramm et al. 2003; Beardmore et al. 2011). Thus, general motives may not well describe the nuanced differences among anglers in terms of their actual behaviors and antecedents of behavior, e.g., preferences for management regulations (Arlinghaus and Mehner 2005). Increasingly, researchers have approached understanding angler heterogeneity through the specialization framework of Bryan (1977) (as further developed in Ditton et al. (1992) and Scott and Shafer (2001)) (Hunt et al. 2023). Recreational specialization, following Bryan (1977), is a multidimensional construct that involves at least three subdimensions—behavioral commitment, skill, and psychological commitment (Scott and Shafer 2001). It was described as "a continuum of behavior from the general to the particular reflected by equipment and skill used in the sport and activity setting preferences" (Bryan 1977). Specialization has been systematically related to the angler's preferences for management regulations (e.g., Bryan 1977; Fisher 1997; Arlinghaus and Mehner 2005; Slaton et al. 2023). It is generally accepted that angler populations are composed of people with different degrees of specialization, which can be interpreted as a different degree of involvement and commitment to the activity (Hunt et al. 2023), with important implications for preferences, behavior, and management (Oh and Ditton 2006; Slaton et al. 2023; Koemle et al. 2024). Importantly, similar to traits assigned to individual fishes or fish species in ecology, specialization is a measure of the fundamental "personality" of an angler and, as such, should have predictive power beyond a given context by "transcending" situations (Hunt et al. 2023).

Previous studies have shown correlations between management preferences and angler specialization exist but are not always consistent across contexts and angler cultures. Bryan (1977) hypothesized that more specialized trout anglers would have a greater understanding of the ecosystem than less specialized anglers, which would result in different management preferences. Gray et al. (2015) indeed found that specialized anglers indeed had a different understanding of ecological cause-and-effect relationships than less specialized anglers. Yet, variation in ecological understanding does not necessarily translate into more specialized anglers accepting more rigid conservation actions better than less specialized anglers (Dorow et al. 2010; Slaton et al. 2023), although this expectation has been frequently expressed (Oh and Ditton 2006). For example, Bryan (1977) assumed more specialized trout anglers would have a more negative view of stocking because stocking was perceived by US freshwater trout anglers to interfere with the genetics and other aspects of the "pureness" of wild trout and because more stocking would also mean increased attractiveness of a local stream to anglers. Yet subsequent research has not confirmed this correlation in other species and contexts, where support for stocking increased, rather than decreased, with angler specialization (Arlinghaus and Mehner 2005; Schroeder et al. 2018; Slaton et al. 2023).

One issue with studies on the correlation of specialization and management preferences is the operationalization of the multidimensional construct, which has been inconsistent in the literature (Scott and Shafer 2001). Research has explored the three subdimensions of specialization that Bryan (1977) originally proposed (Scott and Shafer 2001), but it is not clear that isolated measures of subdimensions would be proper measures of overall specialization degree and the underlying ethics and norms that specialization implies (Hunt et al. 2023). The first subdimension is behavioral commitment, typically measured by frequency of participation and monetary investment in fishing (Ditton et al. 1992). The second is cognitive development, often measured by the level of angling skill and knowledge of the fishery (Salz and Loomis 2005; Beardmore et al. 2013). The third dimension is psychological commitment, such as the centrality of the activity to the participant's lifestyle (Kim et al. 1997) or the involvement in fishing (Kyle et al. 2007*a*). Scott and Shafer (2001) propose to measure and label subdimensions separately and only aggregate them up to a composite specialization score if subdimensions are highly correlated, which is an empirical question. Centrality-to-lifestyle is perhaps the most commonly used measure of the psychological commitment of specialization (Kim et al. 1997; Sutton 2003; Beardmore et al. 2013); it is a subdimension of involvement (Kyle et al. 2007*a*) and is measured by the extent to which the participant's lifestyle and social network are tied to their participation in and pursuit of the activity (Kim et al. 1997). Centrality-to-lifestyle has been applied extensively to recreational fisheries (Sutton and Ditton 2001; Sutton 2003; Beardmore et al. 2013), but when measured in isolation, it is only a subdimension of specialization and should thus be labelled "centrality" instead of specialization. It can be assumed that as fishing becomes more central to the participant's lifestyle, they will be increasingly defined by their participation in fishing and that fishing will increasingly fulfill their leisure needs (Sutton 2003), which should then also translate into support for management actions that are believed to help secure or improve fishing.

The centrality-to-lifestyle framework has frequently been used to characterize angler heterogeneity and connect it to as diverse issues as catch-and-release behaviors (Sutton 2003), site preferences (Beardmore et al. 2011), and management attitudes and preferences (Chipman and Helfrich 1988; Fisher 1997; Arlinghaus and Mehner 2005; Schroeder et al. 2018;

Slaton et al. 2023), especially with respect to harvest regulations. Some of the restrictive management measures assessed in past work include size, bag, or gear limits (Chipman and Helfrich 1988; Oh and Ditton 2006; Hutt and Bettoli 2007; Dorow et al. 2010; Garlock and Lorenzen 2017; Arlinghaus et al. 2019; Slaton et al. 2023), area-based constraints (e.g., marine protected areas; Salz and Loomis 2005; Slaton et al. 2023), effort controls (Dorow et al. 2010), stocking vs. habitat management (Arlinghaus and Mehner 2005; Schroeder et al. 2018), or total catch and release measures (Chipman and Helfrich 1988; Sutton and Ditton 2001). This collective body of work mostly shows that anglers with higher levels of centrality-to-lifestyle are more willing to tolerate more restrictive harvest policies (Oh and Ditton 2006), but have less acceptability of effort controls, such as protected areas (Salz and Loomis 2005; Slaton et al. 2023). Yet, when anglers with higher levels of centrality have higher consumptiveness in certain cultures or angler subgroups, the support for harvest restrictions might also decline with specialization (e.g., Dorow et al. 2010; Bronnmann et al. 2023). More specialized anglers may also be more conflict-prone toward other users of a fishery (e.g., commercial fisheries) when those other users are perceived to interfere with the recreational pursuit (Dorow et al. 2010; Slaton et al. 2023). Yet, in most US freshwater fisheries, anglers with higher levels of centrality-to-lifestyle are often also less consumptive (Sutton 2003); harvest constraints are more easily tolerated by these anglers (Oh and Ditton 2006).

However, management actions common in recreational fisheries also include augmentative actions such as habitat management or stock enhancement that aid in accomplishing management objectives with different approaches (Sass et al. 2017; Radinger et al. 2023). Fewer studies examine the effect of centrality-to-lifestyle on angler preferences for augmentative management measures, specifically stock enhancement. Two studies from North America employed angler centrality-to-lifestyle as a framework to compare angler preferences toward stocking to seasonal closures (Hyman and McMullin 2018) or habitat restoration (Schroeder et al. 2018). In contrast to early qualitative reasoning by Bryan (1977), Schroeder et al. (2018) found more central anglers preferred stocking to a greater extent over habitat management. Indeed, several studies have now shown that as anglers' centrality-to-lifestyle increases, their support for stocking may also rise (Arlinghaus and Mehner 2005; Schroeder et al. 2018; Maurer 2020) rather than diminish, as originally claimed for US freshwater trout anglers (Bryan 1977). The greater support for stocking among more central anglers may be explained by their greater reliance on fishing as a whole, assuming that stocking is believed to be a simple means to maintain catch rates (Arlinghaus et al. 2014). Stocking may, however, negatively affect the perceived quality of the fish stocks by more committed anglers, e.g., decreasing the number of large fish due to growth depression when stocking rates ramp up stock sizes and density-dependent growth reduces growth rate or increasing hybridization rates with wild fish (Lorenzen et al. 2012), which might lower the support of more specialized anglers for stocking when they are aware of these issues (Bryan 1977). As an alternative measure to support fisheries, Arlinghaus and Mehner (2005) found less committed anglers were more in favor of habitat management, whereas Slaton et al. (2023) reported that higher centrality positively correlated with support for habitat restoration among coastal pike (*Esox lucius*) anglers in Germany. Among private fisheries managers in Germany, angling centrality levels held by decision-makers in local angling clubs predicted neither investments into stocking nor habitat management (Fujitani et al. 2020), suggesting that relevance of centrality varies among managers and anglers (Klefoth et al. 2023).

We studied the proposed centrality-management preference relationship in Florida, USA. The state of Florida is the third most populous state, has a humid subtropical climate, and is internationally recognized for its recreational fishing opportunities. Florida has the most days fished annually in the United States and close to 1 million resident freshwater anglers (U.S. Fish and Wildlife Service 2011). Freshwater anglers in Florida target multiple species, though Florida largemouth bass (*Micropterus salmoides*) is the most popular and frequently stocked species by the state management agency (Tringali et al. 2004; Dotson et al. 2013; Garlock et al. 2019; Morales et al. 2020). However, stocking in general can have unintended consequences (Hilborn and Eggers 2000; Leber 2002; Camp et al. 2014), and specifically, stocking of Florida largemouth bass in Florida has rarely demonstrated meaningful increases in fish populations or catch rates (Scharf 2000; Mesing et al. 2008; Thompson et al. 2020). The popularity of largemouth bass as an angling target combined with the paucity of studies demonstrating increased fish populations by stocking Florida largemouth bass creates challenges for fisheries decision-makers. This challenge is exacerbated by uncertainty regarding angler perceptions of stocking—both across a specialization subdimension like centrality to lifestyle and also as compared to alternative management actions. Reducing these uncertainties can help fisheries managers more efficiently allocate resources to maintain or improve angler satisfaction and participation within state-managed freshwater fisheries.

The objective of this study was to investigate how the level of centrality of fishing to an angler's lifestyle correlated with their preferences for stocking and alternative tools such as habitat enhancement in a sample of Florida anglers. We also assessed how centrality-to-lifestyle of fishing affected preferences for multiple management actions, including stocking of specific species. Following more recent studies that challenge early hypotheses by Bryan (1977), we hypothesized that anglers with lower levels of centrality-to-lifestyle would view stocking less positively, particularly when compared to other management actions, than anglers with higher levels of centrality-to-lifestyle. Based on anecdotal evidence from managers and the reported number of fishing days targeting these species groups (U.S. Fish and Wildlife Service 2011), we also hypothesized participants would view stocking of Florida largemouth bass (*M. salmoides*) most positively, followed by panfish, and finally with stocking of striped bass (*Marone saxatilis*) and catfish (*Ictalurus punctatus*) species having similar levels of low support. Finally, we hypothesized participants would view stocking more positively when com-

pared to other management actions, but would come second to habitat maintenance and improvement given the results of previous studies (Chipman and Helfrich 1988; Arlinghaus and Mehner 2005; Connelly et al. 2013; Arlinghaus et al. 2014; Schroeder et al. 2018).

Materials and methods

Survey instrument

We developed an internet-based survey using Qualtrics survey software (Qualtrics, Provo, UT) and distributed it via email to a simple random sample of licensed Florida resident freshwater anglers. The survey aimed to (i) identify and categorize angler types using the metric of centrality of fishing to a participant's lifestyle, (ii) statistically evaluate stocking preferences by angler type, and (iii) statistically evaluate stocking of specific species among other non-restrictive management actions. The full survey is provided in the supplementary materials (Survey Instrument).

The self-administered online survey was developed to collect information from anglers regarding their fishing preferences and experiences, demographics, preferences for types of stocking (e.g., different species and sizes stocked), and preferences for types of relative to other non-stocking management actions (Table S1). The centrality of fishing to each respondent's lifestyle was measured using nine items originally developed by Kim et al. (1997) and since adapted to recreational fishing studies (Sutton 2003; Beardmore et al. 2013; Arlinghaus et al. 2014, 2020; Table S1). The centrality questions were worded as: "Please indicate the level at which you agree or disagree with the following statements". An example statement was "If I stopped fishing, I would probably lose touch with a lot of my friends", and the response categories included a five-point scale: strongly agree (1), somewhat agree (2), neutral (3), somewhat disagree (4), and strongly disagree (5). The wording of each centrality statement is provided in Table S1. Following the centrality-to-lifestyle questions, participants were asked about their view of stocking as a management action itself with five possible responses of (1) "Extremely positive", (2) "Somewhat positive", (3) "Neither positive nor negative", (4) "Somewhat negative", and (5) "Extremely negative". Participants were then asked about to rank their preferences for stocking of specific species as well as their preference for stocking relative to other management actions (e.g., fish habitat maintenance, facility maintenance) with regard to a few target species groups and the stocking of those species. For example, the first ranking question was framed as: "How would you rank these options in the order that you think FWC should stock in the freshwater waterbody you fish most often?" with FWC being the commonly used acronym for the Florida Fish and Wildlife Conservation Commission. The ranking options for this question were fish species that are commonly stocked and targeted in Florida and are Florida largemouth bass, catfish, panfish (e.g., black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), and other sunfish), and striped bass (Kerns et al. 2015; Morales et al. 2020; Hwang et al. 2021). There were also questions about how the various management actions affect other angler decisions, such as how often they choose to fish and their decision to buy a license. Other questions included identifying preferred target species, fishing mode (shore, pier, dock, motorized boat, or non-motorized boat), and demographic information (Supplemental Material Survey Instrument).

Implementation

We randomly sampled a large portion of the licensed freshwater angler population to address potential errors. Our survey medium lends itself to coverage error due to its lack of ability to reach those who did not provide an email address or those who do not need to purchase a license (e.g., anyone over 65 years old in Florida), which should be considered when interpreting the results. The survey was pilot tested with scientists, fisheries managers, and non-scientist freshwater anglers to minimize participants' cognitive load and measurement error. The survey was sent via email to a random sample of 250 000 Florida resident freshwater fishing license holders randomly selected from the Florida Fish and Wildlife Conservation Commission (FWC) license database in February 2021. Upon distribution, duplicates and inoperable email addresses were removed for a final sample size of 228 932. The survey was open for 8 weeks, with reminders sent to those who had not already completed or opted out of the survey each week. Nonresponse bias was examined through wave analysis techniques, where non-responders are assumed to be most closely aligned with those who responded closest to the end of the response period (Lin and Schaeffer 1995; Lewis et al. 2013; Morales et al. 2020). The wave analysis revealed that the participants who responded in the last week were not significantly different than the participants who responded in the first week based on demographic characteristics. All procedures were approved by the Institutional Review Board of the University of Florida.

Analysis

The responses to the nine centrality-to-lifestyle items were analyzed for internal consistency using Cronbach's α and item-total correlation. Both metrics were found to be acceptable, with Cronbach's α over 0.7 and correlation over 0.3 (Table 1) (Tarrant et al. 1997; Morales et al. 2020). Hierarchical cluster analysis was used to determine the number of clusters of anglers. The number of clusters was supported by Ward's and McQuitty's methods (Chipman and Helfrich 1988; Fisher 1997), as well as limited overlap between groups in responses with three clusters compared to other numbers of clusters. We applied a non-hierarchical K-means cluster analysis to the number of groups to determine cluster size (Fisher 1997). The individual questions were tested for possible differences among the three clusters using one-way analysis of variance (ANOVA) and appropriate posthoc tests (Tukey's test or χ^2 analysis, depending on the response metric). We analyzed the results of our research questions using a Bayesian framework to directly compare the posterior effect sizes between the centrality-to-lifestyle clusters, as described below. All analyses were conducted in R (R Core 2021).

Table 1. Reliability and scales used for measuring participant centrality-to-lifestyle.

Centrality-to-lifestyle question	Min	Max	Mean	SD	Item total correlation	Alpha (α) if deleted	Cronbach's alpha (α)
							0.88
If I stopped fishing, I would probably lose touch with a lot of my friends	1	5	2.53	1.27	0.53	0.87	
If I couldn't go fishing, I am not sure what I would do	1	5	3.05	1.37	0.67	0.86	
Because of fishing, I don't have time to spend participating in other leisure activities	1	5	2.08	1.11	0.53	0.87	
Most of my friends are in some way connected with fishing	1	5	3.13	1.29	0.54	0.87	
I consider myself to be somewhat expert at fishing	1	5	3.18	1.14	0.56	0.87	
I find that a lot of my life is organized around fishing	1	5	2.78	1.27	0.77	0.85	
Others would probably say I spend too much time fishing	1	5	2.40	1.29	0.69	0.86	
I would rather go fishing than do most anything else	1	5	3.43	1.23	0.68	0.86	
Other leisure activities don't interest me as much as fishing	1	5	3.13	1.27	0.63	0.86	

Note: $n = 9911$.

Ordinal logistic regression

We developed an ordinal logistic regression adapted from Hazelkorn et al. (2020) to model the probability of a participant, i, selecting one of five ordered discrete possible views toward stocking (1…S possible views). The five possible views were given a numerical value: (1) "Extremely positive", (2) "Somewhat positive", (3) "Neither positive nor negative", (4) "Somewhat negative", and (5) "Extremely negative". We described this probability of choice using a latent continuous logistic response variable, η_i, that is divided into discrete sections using cut-points and transformed into the expected probability using case-wise logit transformations (eq. 1). We further described η_i by a linear mixed model with categorical fixed effects for angler categorization (angler type 1, type 2, or type 3; β_C) and random effects for their view of stocking (ε_k) (eq. 2).

$$(1)\quad Y_i|\eta_i,\theta = \begin{cases} 1-\Phi(\eta-\theta_1) & \text{if } s=1, \\ \Phi(\eta-\theta_{s-1})-\Phi(\eta-\theta_s) & \text{if } 1<s<S, \\ \Phi(\eta-\theta_{S-1}) & \text{and if } s=S. \end{cases}$$

$$(2)\quad \eta_i = \beta_{i,C} + \varepsilon_i$$

where Y_i represents the observed score for a given angler, θ_s describes the cut points of the logistic regression that separate the latent continuous logistic response variable, η_i, along the range of scores (1…S). We assumed the random effects came from a normal distribution with a standard deviation, σ_{ε_i} (eq. 3). We specified normal priors on β_C (eq. 4), a half-normal prior on σ_{ε_i} (eq. 5), and an induced Dirichlet prior as the prior for the cut-points, θ_s. Prior distributions were specified to result in weakly informative priors that provide structural information and regularization (Gelman et al. 2017).

$$(3)\quad \varepsilon_i \sim \text{Normal}(0,\ \sigma_{\varepsilon_i})$$

$$(4)\quad \beta_C \sim \text{Normal}(0,\ 3)$$

$$(5)\quad \sigma_{\varepsilon_i} \sim \text{Normal}(0,\ 3)\,\text{T}(0,)$$

Random coefficients logistic regression

We developed a ranked choice random coefficient logistic regression model to analyze the participants' ranking of specific species stocking options (Florida largemouth bass, catfish, panfish, striped bass, or no stocking) and of possible management actions, including stocking the species above, maintaining and improving fish habitat, and maintaining and improving facilities. Each participant i completes 1:T tasks by making choices from 1:J_t possible options. Each option is described by a vector of choice attributes X_{ijt} with each participant's part-worth preferences β_i generating the expected utility of each choice, μ_{ijt} (eq. 6). We assumed ϵ_{ijt} independent and identically Gumbel distributed, resulting in a log-likelihood in eq. 7.

$$(6)\quad \mu_{ijt} = X_{ijt}\beta_i + \epsilon_{ijt}$$

$$(7)\quad \log(L_{it}) = \sum_{l=1}^{J-1} \log\left(\frac{\exp(\mu_{ijt})}{\sum_{k=l}^{J}\exp(\mu_{ijt})}\right)$$

We wished to describe a participant's part-worth preferences as a function of the expected odds of choosing a given choice as well as how those odds were modified by a participant's centrality-to-lifestyle (eq. 8).

$$(8)\quad \beta_i \sim \text{Multivariate Normal}(\beta + \Gamma W_i,\ \Sigma)$$

where β is the expected log-odds of choosing a given choice regardless of centrality-to-lifestyle, Γ is a loading matrix that loads the individual centrality of lifestyle, W_i, onto the part-worths, and Σ is a covariance matrix. For the sake of implementation, we modified eq. 8 to a vectorized form (eqs. 9 and 10).

$$(9)\quad \beta_i = \beta + +\Gamma W_i + \text{diag}(\tau)\,L_\Omega z_i$$

$$(10)\quad z_i \sim \text{Normal}(0,\ 1)$$

where Σ in eq. 8 is decomposed into the variance-correlation formulation, $\text{diag}(\tau)\,\Omega\text{diag}(\tau)$ with τ describing the vector of

scales of β_i and Ω describing the correlation of the variation across individuals. We further decompose $\text{diag}(\tau)\,\Omega\text{diag}(\tau)$ into the Cholesky factorization, $\text{diag}(\tau)\,L_\Omega z_i$, with L_Ω being the lower triangular Cholesky decomposition of the correlation matrix and z_i being a matrix of random effects for each individual over the potential choices coming from a standard normal distribution. The effect is that β, τ, L_Ω, and Γ imply a hierarchical prior over the individual utilities, β_i.

We employed this method to understand if full rankings of the species and management actions differed by angler type. We also examined the question of species-specific stocking with different management actions using a reranking method. We recategorized all species-specific stocking options as "stocking". Then, we reranked "stocking", "fish habitat", and "facilities" using only the top stocking option to see how the three categories were ranked when stocking was more generalized.

Best- and worst-choice models

We used the utility model to model the best choice, highest ranked item (or worst choice, lowest ranked item) by each participant for both specific species stocking and stocking vs. other management actions. The best choice chosen by a participant can be calculated using eq. 7, which results in the highest utility for any choice j with the log likelihood contribution to total utility for a participant described in eq. 11. We separately examined the best choice (highest rank) and worst choice (lowest rank) participants made by angler type.

$$\log(L_{it}) = \log\left(\frac{\exp(\mu_{ijt})}{\sum_{k=1}^{J}\exp(\mu_{ijt})}\right) \quad (11)$$

We employed this method to understand if full rankings differed by angler type alongside specialization clusters, as well as using the reranking method described above to see how the three categories were ranked when stocking was more generalized.

Priors

We specified a normal prior on τ (eq. 12), a normal prior on β (eq. 13), an LKJ Cholesky prior on L_Ω (eq. 14), and a normal prior on Γ (eq. 15). Prior distributions were specified to result in weakly informative priors that provide structural information and regularization (Gelman et al. 2017).

$$\tau \sim \text{Normal}(0,\ 5) \quad (12)$$

$$\beta \sim \text{Normal}(0,\ 3) \quad (13)$$

$$L_\Omega \sim \text{LKJCorr}(2) \quad (14)$$

$$\Gamma \sim \text{Normal}(0,\ 1) \quad (15)$$

Model runs

The ordinal logistic regression and three random coefficient logistic regressions were implemented in STAN using the Hamiltonian no U-turn sampling algorithm under all default parameters except for the target Metropolis acceptance rate (Monnahan et al. 2017), which was set at 0.9 (ranging from 0 to 1; 0.8 is the default). The model was run over four Markov chains with 2500 warmup samples and 3500 samples for each chain, each initialized randomly with diffuse initial parameter values. Convergence was assessed using the potential scale reduction statistic (Gelman–Rubin Diagnostic R) (Gelman and Rubin 1992), taking values <1.1 under convergence as suggested by Gelman et al. (2013).

Results

We distributed 228 932 surveys to Florida-resident freshwater anglers, and we received 12 225 responses for a 5.3% response rate adjusted for undeliverable surveys. Of the 12 225 returned surveys, 9911 answered all nine centrality-to-lifestyle questions. We compared the demographic profiles of those who completed the centrality-to-lifestyle questions to those who did not and found these two groups to be almost identical (Table 2). Because we were specifically interested in answering questions related to centrality-to-lifestyle, we only used the 9911 complete responses for our analyses. The participants were overwhelmingly male (87.14%) and white (86.91%) with a mean age of 51.44 ± 0.13 (mean ± SE; Table 2). The majority of participants had earned an Associate or Technical college degree (28.44%), followed closely by completed Bachelor's degrees (26.56%; Table 2). The mean number of years of fishing experience was 38.21 ± 0.22, with 32.67 ± 0.49 days fished in the last year (Table 2).

Responses were categorized into three different angler types based on their answers to nine questions surrounding the centrality of fishing to their lifestyle. Type 1 anglers (n = 2807, 28.32%) had the lowest level of centrality of fishing to their lifestyle, meaning that they spend a minimal amount of their leisure time fishing, doing fishing-related activities, or having a minimal number of friendships maintained through fishing. Type 2 anglers (n = 4258, 42.96%) had the middle level of centrality of fishing to their lifestyle, meaning that they spend a little more leisure time than some and less than others on fishing or doing fishing related activities. They might also have a mix of some close friendships that are maintained through fishing. Type 3 anglers (n = 2846, 28.72%) have the highest level of centrality of fishing to their lifestyle, meaning that they spend a significant portion of their leisure time fishing, doing fishing related activities, or having a large portion of friendships maintained through fishing. The three angler groups had some notable demographic differences. A Chi-squared analysis revealed that gender, education, and fishing mode and Tukey's test for the number of days fished in the last year were significantly different between the three angler types (Table 2). We observed that type 3 anglers (the most avid anglers) were significantly younger compared to type 1 and type 2 anglers, which were not significantly different from one another in terms of age. We also observed that type 1 anglers had significantly fewer years of experience than type 2 or type 3 anglers. These three angler types were the lenses through which we examined our research questions.

Table 2. Demographic information of participants.

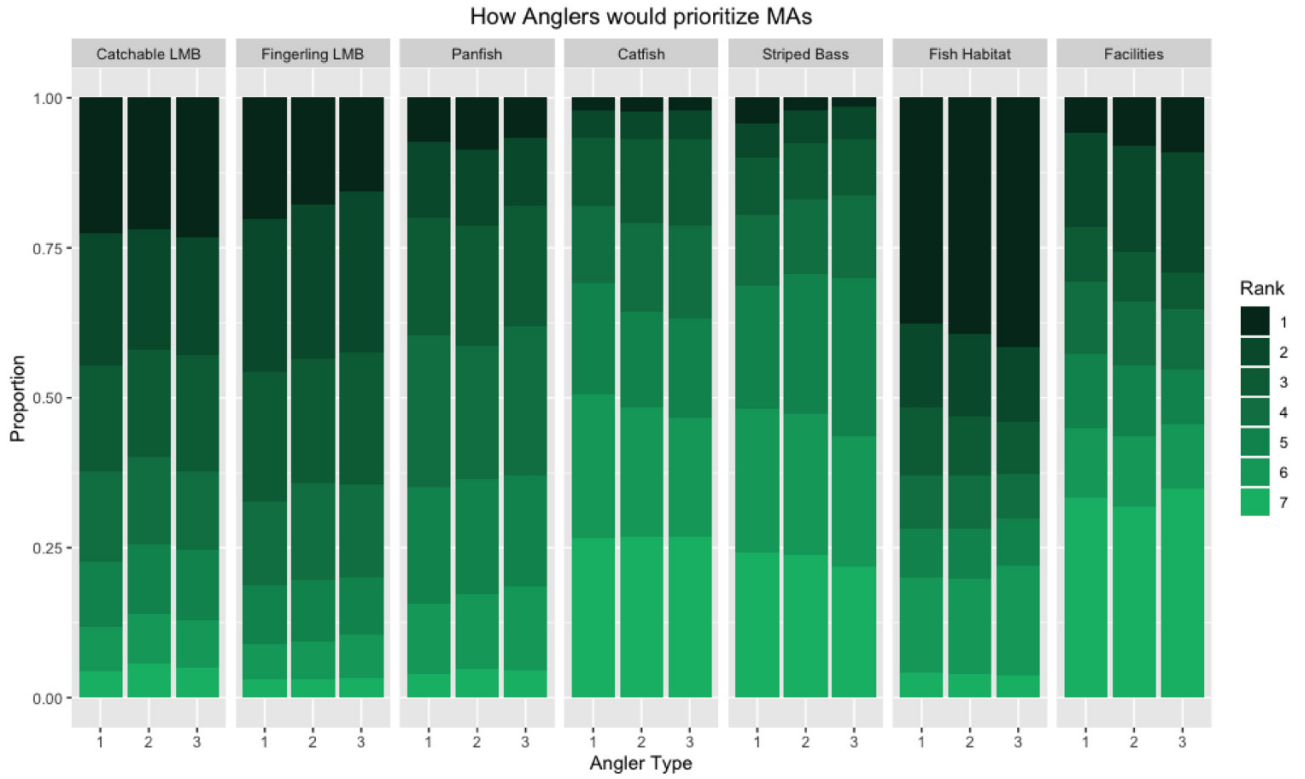
Category	Full sample	Angler type 1	Angler type 2	Angler type 3
n	9911	2807 (28.32%)	4258 (42.96%)	2846 (28.72%)
Age (years)	51.44 ± 0.13	52.17 ± 0.25	52.18 ± 0.20	49.74 ± 0.26***
Sex (%)†††				
Male	87.14	83.31	86.29	91.67
Female	12.74	16.63	13.54	8.23
Years of experience	38.21 ± 0.22	35.11 ± 0.63***	38.76 ± 0.28	38.98 ± 0.31
Days fished in last 365	32.67 ± 0.49	15.89 ± 0.56***	28.95 ± 0.62***	55.48 ± 1.23***
Race (%)				
Asian	1.02	1.23	0.82	1.13
Black	3.94	4.04	4.05	3.68
Hispanic/Latinx	1.88	1.97	1.84	1.86
Indigenous American	1.99	1.77	2.36	1.65
White/Caucasian	86.91	86.15	86.45	88.23
Other	4.26	4.83	4.48	3.46
Education (%)†††				
Associate or technical degree	28.44	26.77	29.20	28.83
Bachelor's degree	26.56	29.58	25.61	24.25
High school	21.49	15.91	22.41	25.11
Graduate or professional degree	18.64	23.47	17.56	15.91
Some high school	1.65	1.02	2.44	2.44
Prefer not to say	3.54	3.25	3.74	3.46
Region (%)				
Northwest	14.10	14.23	14.05	14.04
North Central	13.85	14.85	13.66	13.14
Northeast	27.23	27.91	27.16	26.65
South	18.60	18.62	18.65	18.52
Southwest	26.23	24.39	26.49	27.65
Fishing mode (%)†††				
Dock	6.51	9.92	6.06	3.94
Motorized boat	47.62	36.91	46.35	59.71
Non-motorized boat	8.22	8.42	8.43	7.73
Pier	2.45	3.71	2.47	1.21
Shore	35.19	41.04	36.69	27.41

Note:*** indicates *p*-value <0.001 by Tukey's test; ††† indicates *p*-value <0.001 by χ^2 test.

Upon examining the results of our first research question, how centrality-to-lifestyle impacts views of stocking, analyzed using the ordinal logistic regression model, we observed that there was a positive relationship between angler type and view of stocking. As the level of centrality-to-lifestyle increased (from angler type 1 to angler type 2 to angler type 3), the proportion of anglers in each category with positive views of stocking increased. The ordinal logistic regression converged for all parameters. The posterior check did not show any signs of misfit with the observed view of stocking falling within the 95% credible interval. The categorical fixed effects (β_C) were significant ($p(\beta_1) < 0.05$; $p(\beta_2) < 0.01$; $p(\beta_3) < 0.005$), with a positive effect indicating increasing marginal probabilities as the angler type increased in level of centrality-to-lifestyle. This indicated that as the level of centrality-to-lifestyle increased, the probability of anglers viewing stocking positively also increased. We also saw that type 1 and type 2 anglers were significantly different from type 3 anglers; type 3 anglers viewed stocking more favorably and statistically more positively than the other two angler types. While all angler types viewed stocking, on average, positively, as centrality-to-lifestyle increased, a larger proportion of anglers viewed stocking positively.

For our second question asking participants about management actions, we did not observe any significant impact of participants' centrality-to-lifestyle on their full rankings of management action preferences (Fig. 1). This suggests that there was no specific set of preferences for a particular angler type varying by centrality. Among all anglers, the choice of fish habitat maintenance and improvement was ranked first by anglers overall ($p < 0.001$; Table S2). The worst-choice analysis indicated that facilities were consistently ranked last ($p < 0.001$; Table S3). We did not see any significant results when we generalized stocking no matter which species and compared it to other management actions (henceforth referred to as re-ranked): centrality-to-lifestyle did not have an

Fig. 1. Participant's ranking of various stocking options listed: catchable Florida largemouth bass, fingerling Florida largemouth bass, panfish, catfish, striped bass, fish habitat, and facilities. Angler type is indicated on the *x*-axis, and the proportion of participants' ranks for each option is indicated on the *y*-axis.



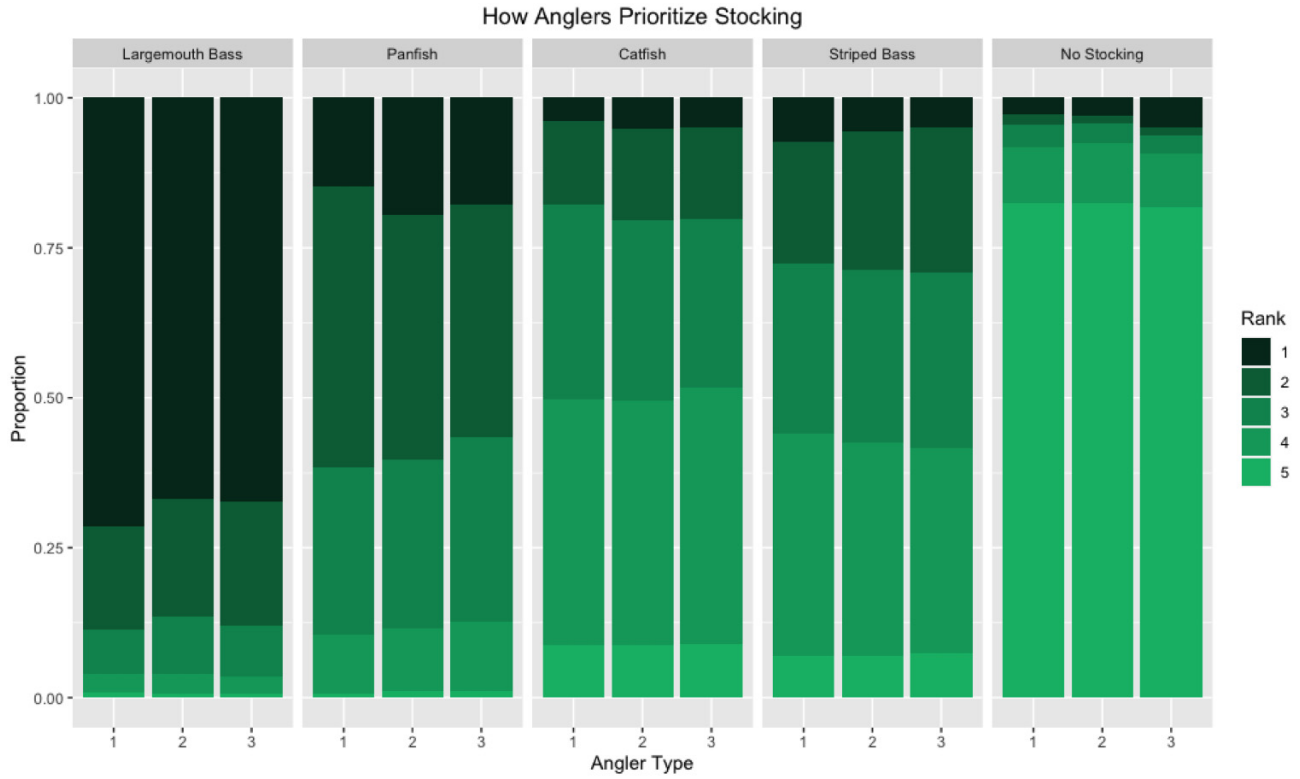
effect on participants' rankings. The lack of significance was also found when we re-ranked the management actions as a whole. When considering the re-ranked data on stocking in general compared to other management actions, we did not find any significant relationships with centrality. While not significant, we did see that the probability of direction of stocking was highly positive (pd = 90%; Table S4) compared to fish habitat and facilities. However, there were no significant results from the worst choice model for the re-ranked data, but the probability of directions of no stocking was highly positive (pd = 100%; Table S5). Overall, we found that there were no strong preferences among anglers in the ranking of management actions, but stronger general preferences for fish habitat maintenance and improvement and slightly less for stocking in the best choice models.

The ranked choice model showed a strong species stocking preference (Fig. 2). We did not observe any significant influence of participants' centrality-to-lifestyle on their rankings of stocking specific species. We did find that, generally, all anglers significantly preferred stocking of Florida largemouth bass ($p < 0.001$, pd = 1; Tables S6 and S7) and significantly disliked no stocking at all ($p < 0.001$, pd = 1; Tables S6 and S7). This suggests that anglers independent of centrality levels strongly preferred stocking of Florida largemouth bass over any of the other options and strongly preferred stocking of some species over no stocking at all. We also found that panfish was significantly preferred by participants after Florida largemouth bass ($p = 0.07$, pd = 99%; Table S6), and that centrality-to-lifestyle had no significant influence on anglers' preference of stocking species as their first or last choice. However, for all participants, our best-choice and worst-choice models confirmed the rank choice model results: anglers significantly preferred stocking Florida largemouth bass over any other option ($p < 0.001$; Table S2), and anglers significantly disliked no stocking compared to stocking of any species ($p < 0.001$; Table S3). Overall, these results indicated that anglers prefer stocking of Florida largemouth bass, followed by panfish species, and that these findings hold independent of centrality levels.

Discussion

Our study provides empirical support for two of our three hypotheses. Our finding that anglers with higher levels of centrality-to-lifestyle support stocking more than less central anglers contrasts with what Bryan (1977) hypothesized in his qualitative pioneering work on US recreational trout anglers, but agrees with more recent studies that employed quantitative techniques such as ours (Arlinghaus and Mehner 2005; Schroeder et al. 2018; Slaton et al. 2023). This discrepancy may be partially explained by the fact that Bryan conceptualized specialization in general using qualitative reasoning applied to a single-species fishery, while we focused on a subdimension of the multidimensional construct of specialization—centrality-to-lifestyle—as empirically as-

Fig. 2. Participant's ranking of various stocking options listed: Florida largemouth bass, panfish, catfish, striped bass, and no stocking. Angler type is indicated on the *x*-axis, and the proportion of participants' ranks for each option is indicated on the *y*-axis.



sessed in a multispecies fishery. We could not replicate the hypotheses by Bryan (1977), similar to another multispecies study where a negative relation between centrality-to-lifestyle and stocking was only revealed for trout anglers (Maurer 2020) but not for other target species (Arlinghaus and Mehner 2005; Schroeder et al. 2018; Slaton et al. 2023). Our results suggest that anglers may view stocking as a means to positively affect catch and other experiential aspects of angling (Arlinghaus et al. 2014; Beardmore et al. 2015) and not focus on the potential deleterious ecological or environmental effects associated with stocking, perhaps because they are invisible and not known to the average angler (Fujitani et al. 2017). This suggests that anglers in our sample, which did not involve trout anglers, generally view stocking positively, similar to many other angler populations (Sass et al. 2017; Klefoth et al. 2023), and that the proportion of anglers who view stocking positively, increases with their level of centrality-to-lifestyle, similar to work in other multi-species contexts (Arlinghaus and Mehner 2005; Schroeder et al. 2018; Maurer 2020; Slaton et al. 2023). Klefoth et al. (2023) showed that the beliefs and attitudes toward stocking may be systematically more positive among anglers than managers, and stocking can easily develop as a panacea for catch-dependent satisfaction, with stocking being an assumed tool among anglers to safeguard it (Sass et al. 2017).

Our results imply that anglers may be satisfied with stocking even without evidence that it improves other management objectives (e.g., catch rates, catch size). Fujitani et al. (2016) found that after passively learning about stocking and its biological risks through scientific seminars, anglers' behavioral intentions about which stocking policies to focus on remained largely unchanged, which was not the case when anglers were actively involved in adaptive stocking experiments (Fujitani et al. 2017). Lack of knowledge about when stocking works and when it fails, as well as a tradition of focusing on stocking as a compensatory measure in fisheries (Sass et al. 2017) can explain why anglers with higher levels of centrality-to-lifestyle supported stocking more. The results also suggest that managers cannot solely rely on anglers' views on stocking when making decisions about management actions that may have broader eco-evolutionary impacts. As stocking may not increase populations as intended (Hühn et al. 2023; Radinger et al. 2023) and perhaps even harm communities and ecosystems when done inappropriately (Terui et al. 2023), managers should consider these factors along with anglers' support of stocking when making management decisions. Our results suggest that stocking in Florida is widely supported by anglers, especially for higher levels of centrality-to-lifestyle anglers, but managers should contemplate the potential ecological outcomes of stocking when considering it as a management action.

Contrary to our hypothesis about management actions, we found that centrality-to-lifestyle did not affect participants' preferences toward a set of management actions, including stocking, habitat management, and facility develop-

ment. This is contrary to the results of Chipman and Helfrich (1988), who, although they used a different categorization procedure, found significant differences between angler specialization levels' preferences for different management actions. Some previous studies have examined stocking as a management action among other management actions, specifically habitat management, and found that centrality-to-lifestyle explains discrimination of angler management preferences across multiple action arenas (including habitat management) (Chipman and Helfrich 1988; Arlinghaus and Mehner 2005; Schroeder et al. 2018), while ours only revealed an association with stocking but not with habitat improvement. While previous studies have compared multiple management options and found that stocking was preferred over other actions (Arlinghaus and Mehner 2003; Connelly et al. 2013; Arlinghaus et al. 2014, 2019; Schroeder et al. 2018), there are no studies that we could find that have included questions about multiple stocking species and other management actions in the same question format. Our empirical findings illustrate that anglers' support of one management action, such as stocking, does not limit their preference for another, such as fish habitat maintenance and improvement. Importantly, when we combined all stocking options of different species into one option in our re-ranking analysis, anglers did not indicate a significant preference for stocking and instead preferred habitat improvement, independent of centrality level. This is an important finding highlighting that anglers in Florida may focus on well-designed and communicated habitat improvement measures over stocking, which has been found empirically to provide a greater impact on stock sizes under certain conditions (Sass et al. 2017; Radinger et al. 2023). Managers should consider anglers' responses to multiple categories of management actions and not just details of one when attempting to understand how angler position themselves around "stocking" or "habitat improvement".

Our study found that anglers have species-specific stocking preferences regardless of centrality-to-lifestyle. These results provide managers who choose stocking as a management action empirical support to stock Florida largemouth bass, as that was anglers' first preference—a long suspected angler preference. We also saw that panfish is often anglers' second choice, which includes black crappie, another popular fishery in the state (Hwang et al. 2021). Previous studies have examined anglers' target species preference based on centrality-to-lifestyle and catch orientation and examined the frequency and density of species-specific stocking preferences, but those studies focused primarily on German anglers and species in that region (Arlinghaus et al. 2014, 2019, 2020; Koemle et al. 2021). This appears to be the first study to ask anglers of different levels of centrality-to-lifestyle to compare stocking between different species in the US. No previous studies of stocking that we could find included the option of no stocking (of any species) as an option for participants when considering stocking of specific species. The results of this study support anglers for stocking of Florida largemouth bass and panfish broadly, and here they actually support a decision to manage for the preferences of the "average" angler, contrary to some previous studies (Aas and Ditton 1998; Oh and Ditton 2006). The ability to make management decisions based on the "average" angler can help streamline the management decision-making process, which can make decision-making simpler as angler preferences evolve. Nevertheless, as anglers are often used to expecting stocking, and may perceive more immediate rewards from such management activities, any move away from stocking to habitat management may work best with a transparent communication campaign that explains the shift (Sass et al. 2017).

Limitations

There are a number of limitations that must be considered when drawing inferences from this study. While our wave analysis revealed that the first and last set of participants were not significantly different in terms of the demographic characteristics collected from all participants, they are noticeably different than those of the sampled Florida population, with an overrepresentation of white males (U.S. Fish and Wildlife Service 2011). Using a different sampling technique, such as stratified random sampling, would likely have addressed this issue and coverage error challenges to a certain extent, but some level of non-response bias might be unavoidable. Therefore, the data we present are unlikely to represent the entire Florida and should be viewed with caution. As for the centrality-to-lifestyle specialization, Bryan (1977) and Ditton et al. (1992) both discuss recreationalist specialization as a multi-dimensional framework that can be difficult to operationalize (Scott and Shafer 2001). Our work thus derives implications for centrality-to-lifestyle, not for specialization as a whole. Also, we included only categories of some stocked species, such as panfish, which includes a few species that are stocked in Florida. The panfish category includes a number of different species, so it would be important to investigate exactly which panfish species are of particular interest to anglers. Finally, previous studies explored other human dimension constructs (e.g., catch orientation) in addition to centrality-to-lifestyle, whereas we focused solely on centrality-to-lifestyle. Including more human dimension constructs in future studies is advisable to better explain what drives angler preferences for management.

Management implications

Our work provides empirical evidence and support for the widely held belief, which before this study relied solely on anecdotal evidence, that Florida anglers like stocking and prefer Florida largemouth bass, while also expanding our understanding of their salient preferences for habitat management. The combined insights from our analyses show that stocking, particularly of Florida largemouth bass, has strong positive appeal across all angler types, implying that managers can stock to achieve various management goals with little opposition from anglers, similar to other countries (Arlinghaus et al. 2022). Stocking Florida largemouth bass and panfish species, anglers' first and second preferences, would receive particularly strong support. However, managers should also consider anglers' strong support for habitat management when deciding between management actions, as this action may deliver more actual benefits to fish

(and, in turn, anglers) than stocking (Radinger et al. 2023). Anglers can simultaneously support multiple management actions that align with their preferences. Our results illustrate the potential for management to rely on habitat management as an alternative to stocking and that this reliance can be consistent with angler preferences in Florida. Yet, any change away from stocking may require proper communication, given the history of stocking as the prime enhancement tool in freshwater fisheries management.

Conclusion

Overall, the results of our survey indicate that stocking is well liked and a supported management action across all centrality-to-lifestyle levels. Managers should feel confident that stocking Florida largemouth bass and, secondarily, panfish species will be supported by all angler types in Florida. Our work also revealed support for stocking of at least one species, even a less preferred species, over no stocking at all, and that this support rises with angler centrality. Yet, when faced with various management actions, all anglers generally supported fish habitat maintenance and improvement, with stocking of any species coming second. Managers can therefore assume that the preference of all anglers, independent of centrality level, is for habitat management as well as species-specific stocking in Florida, meaning that such actions will receive abundant support by the angler constituency. However, given the rather low response rate of our survey, any changes to management will benefit from transparent communication about aims and procedures.

Acknowledgements

Our manuscript was improved by two anonymous reviewers, to whom we are grateful for.

Article information

History dates

Received: 14 September 2023
Accepted: 24 February 2024
Accepted manuscript online: 11 March 2024
Version of record online: 22 May 2024

Data availability

The research survey data can be obtained via email at perryd@ufl.edu.

Author information

Author ORCIDs

Diana Perry https://orcid.org/0000-0001-9758-3828

Author notes

Kai Lorenzen served as Associate Editor at the time of manuscript review and acceptance and did not handle peer review and editorial decisions regarding this manuscript.

Author contributions

Conceptualization: DP, CC, NM, EC
Data curation: DP, ZAS
Formal analysis: DP, ZAS
Funding acquisition: EC
Investigation: DP, ZAS
Methodology: DP, ZAS, CC, NM
Project administration: EC
Supervision: EC
Validation: DP, ZAS
Visualization: DP
Writing – original draft: DP, ZAS
Writing – review & editing: DP, CC, NM, RA, KL, EC

Competing interests

The authors declare there are no competing interests.

Funding information

The funding for this work was supported by the United States Department of Interior (grant number F22AF03488), the Florida Fish and Wildlife Conservation Commission (grant number 22115), and the USDA National Institute of Food and Agriculture, Research Capacity Fund (Hatch) project 7005435.

Supplementary material

Supplementary data are available with the article at https://doi.org/10.1139/cjfas-2023-0269.

References

Aas, Ø., and Ditton, R. 1998. Human dimensions perspective on recreational fisheries management: implications for Europe.

Anderson, D.K., Ditton, R.B., and Hunt, K.M. 2007. Measuring angler attitudes toward catch-related aspects of fishing. Hum. Dim. Wildlife, **12**(3): 181–191. doi:10.1080/10871200701323066.

Arlinghaus, R. 2006. On the apparently striking disconnect between motivation and satisfaction in recreational fishing: the case of catch orientation of German anglers. N. Am. J. Fish. Manage. **26**(3): 592–605. doi:10.1577/M04-220.1.

Arlinghaus, R., and Mehner, T. 2003. Management preferences of urban anglers. Fisheries, **28**(6): 10–17. doi:10.1577/1548-8446(2003)28[10:MPOUA]2.0.CO;2.

Arlinghaus, R., and Mehner, T. 2005. Determinants of management preferences of recreational anglers in Germany: habitat management versus fish stocking. Limnologica, **35**(1): 2–17. doi:10.1016/j.limno.2004.10.001.

Arlinghaus, R., Beardmore, B., Riepe, C., and Pagel, T. 2019. Species-specific preference heterogeneity in German freshwater anglers, with implications for management. J. Outdoor Recreat. Tour. 100216. doi:10.1016/j.jort.2019.03.006.

Arlinghaus, R., Beardmore, B., Riepe, C., and Pagel, T. 2020. Species-specific preference heterogeneity in German freshwater anglers, with implications for management. J. Outdoor Recreat. Tour. **32**: 100216. doi:10.1016/j.jort.2019.03.006.

Arlinghaus, R., Beardmore, B., Riepe, C., Meyerhoff, J., and Pagel, T. 2014. Species-specific preferences of German recreational anglers for freshwater fishing experiences, with emphasis on the intrinsic util-

ities of fish stocking and wild fishes. J. Fish Biol. **85**(6): 1843–1867. doi:10.1111/jfb.12546. PMID: 25469949.

Arlinghaus, R., Riepe, C., Theis, S., Pagel, T., and Fujitani, M. 2022. Dysfunctional information feedbacks cause the emergence of management panaceas in social-ecological systems: the case of fish stocking in inland recreational fisheries. J. Outdoor Recreat. Tour. **38**: 100475. doi:10.1016/j.jort.2021.100475.

Beardmore, B., Haider, W., Hunt, L.M., and Arlinghaus, R. 2011. The importance of trip context for determining primary angler motivations: are more specialized anglers more catch-oriented than previously believed? N. Am. J. Fish. Manage. **31**(5): 861–879. doi:10.1080/02755947.2011.629855.

Beardmore, B., Haider, W., Hunt, L.M., and Arlinghaus, R. 2013. Evaluating the ability of specialization indicators to explain fishing preferences. Leis. Sci. **35**(3): 273–292. doi:10.1080/01490400.2013.780539.

Beardmore, B., Hunt, L.M., Haider, W., Dorow, M., and Arlinghaus, R. 2015. Effectively managing angler satisfaction in recreational fisheries requires understanding the fish species and the anglers. Can. J. Fish. Aquat. Sci. **72**(4): 500–513. doi:10.1139/cjfas-2014-0177.

Birdsong, M., Hunt, L.M., Beardmore, B., Dorow, M., Pagel, T., and Arlinghaus, R. 2022. Does the relevance of catch for angler satisfaction vary with social-ecological context? A study involving angler cultures from West and East Germany. Fish. Res. **254**: 106414. doi:10.1016/j.fishres.2022.106414.

Bronnmann, J., Koemle, D., Meyerhoff, J., Weltersbach, M.S., Strehlow, H.V., and Arlinghaus, R. 2023. Willingness to pay for harvest regulations and catch outcomes in recreational fisheries: a stated preference study of German cod anglers. Fish. Res. **259**: 106536. doi:10.1016/j.fishres.2022.106536.

Bryan, H. 1977. Leisure value systems and recreational specialization: the case of trout fishermen. J. Leis. Res. **9**(3): 174–187. doi:10.1080/00222216.1977.11970328.

Camp, E.V., Lorenzen, K., Ahrens, R.N.M., and Allen, M.S. 2014. Stock enhancement to address multiple recreational fisheries objectives: an integrated model applied to red drum Sciaenops ocellatus in Florida: recreational stocking integrated assessment. J. Fish Biol. **85**(6): 1868–1889. doi:10.1111/jfb.12548.

Chipman, B.D., and Helfrich, L.A. 1988. Recreational specializations and motivations of Virginia River anglers. N. Am. J. Fish. Manage. 390–398. doi:10.1577/1548-8675(1988)0082.3.CO;2.

Connelly, N.A., Keeler, S., and Knuth, B.A. 2013. Understanding angler preferences for species and water bodies: importance for New York's future fisheries management. Hum. Dim. Wildlife, **18**(5): 386–402. doi:10.1080/10871209.2013.822133.

Ditton, R.B., and Hunt, K.M. 1996. Demographics, participation, attitudes, management preferences, and trip expenditures of Texas anglers. HD-605. Texas A&M University, College Station.

Ditton, R.B., Holland, S.M., and Anderson, D.K. 2002. Recreational fishing as tourism. Fisheries, **27**(3): 17–24. doi:10.1577/1548-8446(2002)027⟨0017:RFAT⟩2.0.CO;2.

Ditton, R.B., Loomis, D.K., and Choi, S. 1992. Recreation specialization: reconceptualization from a social worlds perspective. J. Leis. Res. **24**(1): 33–51. doi:10.1080/00222216.1992.11969870.

Dorow, M., Beardmore, B., Haider, W., and Arlinghaus, R. 2010. Winners and losers of conservation policies for European eel, Anguilla anguilla: an economic welfare analysis for differently specialised eel anglers. Fish. Manage. Ecol. **17**(2): 106–125. doi:10.1111/j.1365-2400.2009.00674.x.

Dotson, J.R., Allen, M.S., Kerns, J.A., and Pouder, W.F. 2013. Utility of restrictive harvest regulations for trophy largemouth bass management. N. Am. J. Fish. Manage. **33**(3): 499–507. doi:10.1080/02755947.2013.769921.

Fedler, A.J., and Ditton, R.B. 1986. A framework for understanding the consumptive orientation of recreational fishermen. Environ. Manage. **10**: 221–227. doi:10.1007/BF01867360.

Fedler, A.J., and Ditton, R.B. 1994. Understanding angler motivations in fisheries management. Fisheries, **19**(4): 6–13. doi:10.1577/1548-8446(1994)019⟨0006:UAMIFM⟩2.0.CO;2.

Fisher, M.R. 1997. Segmentation of the angler population by catch preference, participation, and experience: a management-oriented application of recreation specialization. N. Am. J. Fish. Manage. **17**(1): 1–10. doi:10.1577/1548-8675(1997)017⟨0001:SOTAPB⟩2.3.CO;2.

Fujitani, M., Mcfall, A., Randler, C., and Arlinghaus, R. 2017. Participatory adaptive management leads to environmental learning outcomes extending beyond the sphere of science. Sci. Adv. **3**(6): e1602516. doi:10.1126/sciadv.1602516.

Fujitani, M.L., Mcfall, A., Randler, C., and Arlinghaus, R. 2016. Efficacy of lecture-based environmental education for biodiversity conservation: a robust controlled field experiment with recreational anglers engaged in self-organized fish stocking. J. Appl. Ecol. **53**(1): 25–33. doi:10.1111/1365-2664.12560.

Fujitani, M.L., Riepe, C., Pagel, T., Buoro, M., Santoul, F., Lassus, R., et al. 2020. Ecological and social constraints are key for voluntary investments into renewable natural resources. Global Environ. Change, **63**: 102125. doi:10.1016/j.gloenvcha.2020.102125.

Garlock, T.M., and Lorenzen, K. 2017. Marine angler characteristics and attitudes toward stock enhancement in Florida. Fish. Res. **186**: 439–445. doi:10.1016/j.fishres.2016.08.017.

Garlock, T.M., Camp, E.V., and Lorenzen, K. 2019. Efficacy of largemouth bass stock enhancement in achieving fishery management objectives in Florida. Fish. Res. **213**: 180–189. doi:10.1016/j.fishres.2019.01.010.

Gelman, A., and Rubin, D.B. 1992. Inference from iterative simulation using multiple sequences. Stat. Sci. **7**(4): 457–472. doi:10.1214/ss/1177011136.

Gelman, A., Carlin, J.B., Stern, H.S., Dunson, D.B., Vehtari, A., and Rubin, D.B. 2013. Bayesian data analysis. CRC Press, Boca Raton, FL.

Gelman, A., Simpson, D., and Betancourt, M. 2017. The prior can often only be understood in the context of the likelihood. Entropy, **19**(10): 555. doi:10.3390/e19100555.

Gray, S., Hilsberg, J., Mcfall, A., and Arlinghaus, R. 2015. The sructure and function of angler mental models about fish population ecology: the influence of specialization and target species. J. Outdoor Recreat. Tour. **12**: 1–13. doi:10.1016/j.jort.2015.09.001.

Gundelund, C., Arlinghaus, R., Birdsong, M., Flávio, H., and Skov, C. 2022. Investigating angler satisfaction: the relevance of catch, motives and contextual conditions. Fish. Res. **250**: 106294. doi:10.1016/j.fishres.2022.106294.

Hazelkorn, R.A., Wells, R.S., Siders, Z.A., Delynn, R., and Lovewell, G.N. 2020. Physical maturity in common bottlenose dolphins (*Tursiops truncatus*) from Sarasota Bay, Florida. Mar. Mamm. Sci. **36**(4): 1309–1321. doi:10.1111/mms.12733.

Hendee, J., Potter, D., and Clark, R. 1974. Forest game management: a multiple satisfaction approach. *In* Wildlife and forest management in the Pacific Northwest. Proceedings of a symposium.

Hilborn, R., and Eggers, D. 2000. A review of the hatchery programs for pink salmon in Prince William Sound and Kodiak Island, Alaska. Trans. Am. Fish. Soc. **129**(2): 333–350. doi:10.1577/1548-8659(2000)129⟨0333:AROTHP⟩2.0.CO;2.

Hühn, D., Gwinn, D.C., Shaw, S.L., Alós, J., Allen, M.S., Pagel, T., et al. 2023. Density-and size-dependent mechanisms modulate the outcome of stocking in a naturally recruiting freshwater piscivore (northern pike, *Esox lucius*): a replicated whole-lake experiment. Fish. Res. **267**: 106799. doi:10.1016/j.fishres.2023.106799.

Hunt, K.M., Hutt, C.P., Schlechte, J.W., and Buckmeier, D.L. 2012. Demographics, attitudes, preferences, and satisfaction of Texas freshwater catfish anglers. *In* Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies. pp. 94–101.

Hunt, L., Arlinghaus, R., Scott, D., and Kyle, G.T. 2023. Diversity of anglers: drivers and implications for fisheries management. Chapter 5. *In* Angler recruitment, retention, and reactivation: the future of fisheries and aquatic conservation summary and synthesis. American Fisheries Society. pp. 1–28.

Hutt, C.P., and Bettoli, P.W. 2007. Preferences, specialization, and management attitudes of trout anglers fishing in Tennessee tailwaters. N. Am. J. Fish. Manage. **27**(4): 1257–1267. doi:10.1577/M05-215.1.

Hwang, J., Bi, X., Morales, N., and Camp, E.V. 2021. The economic value of freshwater fisheries in Florida: an application of the travel cost method for black crappie fishing trips. Fish. Res. **233**: 105754. doi:10.1016/j.fishres.2020.105754.

Hyman, A.A., and Mcmullin, S.L. 2018. Specialization and characterization of stocked-trout anglers in Virginia, USA. N. Am. J. Fish. Manage. **38**(6): 1394–1403. doi:10.1002/nafm.10237.

Johnston, F.D., Arlinghaus, R., and Dieckmann, U. 2010. Diversity and complexity of angler behaviour drive socially optimal input and out-

put regulations in a bioeconomic recreational-fisheries model. Can. J. Fish. Aquat. Sci. **67**(9): 1507–1531. doi:10.1139/F10-046.

Kerns, J.A., Allen, M.S., Dotson, J.R., and Hightower, J.E. 2015. Estimating regional fishing mortality for freshwater systems: a Florida largemouth bass example. N. Am. J. Fish. Manage. **35**(4): 681–689. doi:10.1080/02755947.2015.1040561.

Kim, S.-S., Scott, D., and Crompton, J.L. 1997. An exploration of the relationships among social psychological involvement, behavioral involvement, commitment, and future intentions in the context of birdwatching. J. Leis. Res. **29**(3): 320–341. doi:10.1080/00222216.1997.11949799.

Klefoth, T., Wegener, N., Meyerhoff, J., and Arlinghaus, R. 2023. Do anglers and managers think similarly about stocking, habitat management and harvest regulations? Implications for the management of community-governed recreational fisheries. Fish. Res. **260**: 106589. doi:10.1016/j.fishres.2022.106589.

Koemle, D., Beardmore, B., Dorow, M., and Arlinghaus, R. 2021. The human dimensions of recreational anglers targeting freshwater species in coastal ecosystems, with implications for management. N. Am. J. Fish. Manage. **41**(5): 1572–1590. doi:10.1002/nafm.10672.

Koemle, D., Gassler, B., Kyle, G., Meyerhoff, J., and Arlinghaus, R. 2024. How involvement drives decision rules behind stated preferences for recreational-fisheries management. J. Environ. Manage. **349**: 119604. doi:10.1016/j.jenvman.2023.119604.

Kyle, G., Absher, J., Norman, W., Hammitt, W., and Jodice, L. 2007a. A modified involvement scale. Leis. Stud. **26**(4): 399–427. doi:10.1080/02614360600896668.

Kyle, G., Norman, W., Jodice, L., Graefe, A., and Marsinko, A. 2007b. Segmenting anglers using their consumptive orientation profiles. Hum. Dim. Wildlife, **12**(2): 115–132. doi:10.1080/10871200701196066.

Leber, K.M. 2002. Advances in marine stock enhancement: shifting emphasis to theory and accountability. In Responsible marine aquaculture. pp. 79–90.

Lewis, E.F., Hardy, M., and Snaith, B. 2013. Estimating the effect of nonresponse bias in a survey of hospital organizations. Eval. Health Profess. **36**(3): 330–351. doi:10.1177/0163278713496565.

Lin, I.-F., and Schaeffer, N.C. 1995. Using survey participants to estimate the impact of nonparticipation. Public Opin. Q. **59**(2): 236–258. doi:10.1086/269471.

Lorenzen, K., Beveridge, M.C.M., and Mangel, M. 2012. Cultured fish: integrative biology and management of domestication and interactions with wild fish. Biol. Rev. **87**(3): 639–660. doi:10.1111/j.1469-185X.2011.00215.x.

Matsumura, S., Beardmore, B., Haider, W., Dieckmann, U., and Arlinghaus, R. 2019. Ecological, angler, and spatial heterogeneity drive social and Ecological outcomes in an integrated landscape model of freshwater recreational fisheries. Rev. Fish. Sci. Aquacult. **27**(2): 170–197. doi:10.1080/23308249.2018.1540549.

Maurer, S. 2020. Influence of anglers specialization on their attitudes, functional beliefs, norms and behavioral intensions towards fish stocking with implications for management and conservation. University of Potsdam.

Mesing, C.L., Cailteux, R.L., Strickland, P.A., Long, E.A., and Rogers, M.W. 2008. Stocking of advanced-fingerling largemouth bass to supplement year-classes in Lake Talquin, Florida. N. Am. J. Fish. Manage. **28**(6): 1762–1774. doi:10.1577/M07-165.1.

Monnahan, C.C., Thorson, J.T., and Branch, T.A. 2017. Faster estimation of Bayesian models in ecology using Hamiltonian Monte Carlo. Methods Ecol. Evol. **8**(3): 339–348. doi:10.1111/2041-210X.12681.

Morales, N., Camp, Ed, and Cleary, M. 2020. Modeling target species selection behavior among diverse freshwater anglers in Florida, USA. Fish. Res. **231**: 105693. doi:10.1016/j.fishres.2020.105693.

Oh, C.-O., and Ditton, R.B. 2006. Using recreation specialization to understand multi-attribute management preferences. Leis. Sci. **28**(4): 369–384. doi:10.1080/01490400600745886.

Potts, W.M., Downey-Breedt, N., Obregon, P., Hyder, K., Bealey, R., and Sauer, W.H.H. 2020. What constitutes effective governance of recreational fisheries?—a global review. Fish Fish. **21**(1): 91–103. doi:10.1111/faf.12417.

R Core 2021. R: A language and environment for statistical computing. Vienna Austria. Available from https://www.r-project.org/.

Radinger, J., Matern, S., Klefoth, T., Wolter, C., Feldhege, F., Monk, C.T., and Arlinghaus, R. 2023. Ecosystem-based management outperforms species-focused stocking for enhancing fish populations. Science, **379**(6635): 946–951. doi:10.1126/science.adf0895.

Salz, R.J., and Loomis, D.K. 2005. Recreation specialization and anglers' attitudes towards restricted fishing areas. Hum. Dim. Wildlife, **10**(3): 187–199. doi:10.1080/10871200591003436.

Sass, G.G., Rypel, A.L., and Stafford, J.D. 2017. Inland fisheries habitat management: lessons learned from wildlife ecology and a proposal for change. Fisheries, **42**(4): 197–209. doi:10.1080/03632415.2017.1276344.

Scharf, F.S. 2000. Patterns in abundance, growth, and mortality of juvenile red drum across estuaries on the Texas coast with implications for recruitment and stock enhancement. Trans. Am. Fish. Soc. **129**(6): 1207–1222. doi:10.1577/1548-8659(2000)129⟨1207:PIAGAM⟩2.0.CO;2.

Schramm, H.L., Gerard, P.D., and Gill, D.A. 2003. The importance of environmental quality and catch potential to fishing site selection by freshwater anglers in Mississippi. N. Am. J. Fish. Manage. **23**(2): 512–522. doi:10.1577/1548-8675(2003)023%3c0512:TIOEQA%3e2.0.CO;2.

Schroeder, S.A., Fulton, D.C., Altena, E., Baird, H., Dieterman, D., and Jennings, M. 2018. The influence of angler values, involvement, catch orientation, satisfaction, agency trust, and demographics on support for habitat protection and restoration versus stocking in publicly managed waters. Environ. Manage. **62**(4): 665–677. doi:10.1007/s00267-018-1067-9.

Scott, D., and Shafer, C.S. 2001. Recreational specialization: a critical look at the construct. J. Leis. Res. **33**(3): 319–343. doi:10.1080/00222216.2001.11949944.

Silwal, P., Poudyal, N.C., Engman, A., Chen, X., and Cavasos, K. 2023. Catch orientation and public lake stocking preferences: a typology of freshwater anglers. Fish. Res. **257**: 106500. doi:10.1016/j.fishres.2022.106500.

Slaton, C., Koemle, D., Birdsong, M., and Arlinghaus, R. 2023. Explaining attitudes to management actions and beliefs about other user groups and conservation with angler characteristics: a case study in a coastal pike (*Esox lucius*) fishery in the southern Baltic Sea, Germany. Fish. Res., **263**: 106669. doi:10.1016/j.fishres.2023.106669.

Sutton, S. 2003. Personal and situational determinants of catch-and-release choice of freshwater anglers. Hum. Dim. Wildlife, **8**(2): 109–126. doi:10.1080/10871200304300.

Sutton, S.G., and Ditton, R.B. 2001. Understanding catch-and-release behavior among U.S. Atlantic bluefin tuna anglers. Hum. Dim. Wildlife, **6**(1): 49–66. doi:10.1080/10871200152668698.

Tarrant, M.A., Bright, A.D., and Ken Cordell, H. 1997. Attitudes toward wildlife species protection: assessing moderating and mediating effects in the value-attitude relationship. Hum. Dim. Wildlife, **2**(2): 1–20. doi:10.1080/10871209709359091.

Terui, A., Urabe, H., Senzaki, M., and Nishizawa, B. 2023. Intentional release of native species undermines ecological stability. Proc. Natl. Acad. Sci. U.S.A. **120**(7): e2218044120. doi:10.1073/pnas.2218044120.

Thompson, B.C., Porak, W.F., Pouder, W.F., and Camp, E.V. 2020. Survival of advanced-fingerlings of Florida largemouth bass stocked in small Florida lakes. N. Am. J. Fish. Manage. **40**(6): 1532–1544. doi:10.1002/nafm.10522.

Tringali, M.D., Bert, T.M., Cross, F, Dodrill, J.W., Gregg, L.M., Halstead, W.G. et al. 2004. Genetic policy for the release of finfishes in Florida. Florida Fish and Wildlife Conservation Commission.

U.S. Fish and Wildlife Service. 2011. National survey of fishing, hunting, and wildlife-associated recreation. p. 94.

van Poorten, B.T., and Camp, E.V. 2019. Addressing challenges common to modern recreational fisheries with a buffet-style landscape management approach. Rev. Fish. Sci. Aquacult. **27**(4): 393–416. doi:10.1080/23308249.2019.1619071.

Wilde, G.R., and Ditton, R.B. 1994. A management-oriented approach to understanding diversity among largemouth bass anglers. N. Am. J. Fish. Manage. **14**(1): 34–40. doi:10.1577/1548-8675(1994)014⟨0034:AMOATU⟩2.3.CO;2.

Wilde, G.R., Riechers, R.K., and Ditton, R.B. 1998. Differences in attitudes, fishing motives, and demographic characteristics between tournament and nontournament black bass anglers in Texas. N. Am. J. Fish. Manage. **18**(2): 422–431. doi:10.1577/1548-8675(1998)018⟨0422:DIAFMA⟩2.0.CO;2.