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Early pandemic recreational fishing patterns across the urban-to-rural gradient in the U.S.

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ABSTRACT

In 2020, the SARS-CoV-2 (COVID-19) pandemic disrupted individual and social behaviors and norms, including outdoor activities. A recreational angling survey of 18,000 licensed anglers from 10 states (AR, CT, FL, IA, MO, NC, SC, TX, UT, WY) was conducted in summer 2020 to characterize recreational fishing trends during the first few months of the pandemic. The study presented here builds off this survey by combining the survey data with county-level human population density and spring 2020 per capita COVID-19 cases to understand how anglers responded to the pandemic along the urban-to-rural continuum. Specifically, we wanted to know if population density or COVID-19 cases per capita influenced angler-reported 1) changes in license sales, 2) number of fishing trips, and 3) motivation for fishing. Overall results suggest that per capita COVID-19 cases were more influential in driving angler behavior than population density in the early pandemic (01 March 2020–31 May 2020). At the onset of the pandemic, high COVID-19 case counts were associated with an uptick in recreational angling activity. In counties with greater COVID-19 case counts, there was greater angler recruitment (i.e., attraction of new individuals to recreational fishing) and earlier license purchases. Anglers aged ≥40 years and earning ≥$50,000 living in areas of greater per capita COVID-19 cases also went on more fishing trips than they typically would. Angler motivations varied across gradients of population density and per capita COVID-19 cases: anglers living in areas of higher population densities were more likely to report fishing for *stress relief, sport,* and *competition among friends*, and anglers living in areas of higher per capita COVID-19 cases were more likely to report fishing for *sport* and because they had *free time* and less likely to report fishing for *food*. Management efforts can focus on retaining and reactivating pandemic anglers.

1. Introduction

Recreational angling (i.e., fishing with the primary objective of enjoyment) is one of the most popular outdoor recreation activities in the United States, with over 50 million annual participants in recent years (Outdoor Foundation, 2022). Anglers hail from all regions of the U.S. and represent diverse ages, income levels, and educational levels (Recreational Boating and Fishing Foundation, 2021). Because anglers are a diverse group, we seek to examine behavioral differences among urban and rural anglers during the early portion of the SARS-CoV-2 pandemic (hereafter COVID-19) from 01 March 2020–31 May 2020.

Distinct trends in fishing activity emerge across the urban-to-rural gradient in the U.S. Most recreational anglers in the U.S. live in rural or suburban communities,[1] with only about 10% coming from urban communities despite urban communities accounting for over 80% of the population in the U.S. (American Sportfishing Association, 2015). Churn rate, the proportion of anglers who may not renew their fishing licenses, is higher among urban anglers than rural or suburban anglers (American Sportfishing Association, 2015). Like angler participation, angler motivation also varies across the urban-to-rural gradient. A study comparing urban and rural anglers in Arkansas found that rural anglers tended to value fishing as a way to get out in nature, whereas urban anglers tended to value catch, on-site amenities, and safety (Hutt and Neal, 2010). In general, however, a knowledge gap exists with respect to understanding

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[1] *Urban*, *suburban*, and *rural* definitions are variable, and we do not adopt any specific enumerations in our work to define these terms. We refer to them on a relative scale of population density, which is the continuous variable we consider to represent these terms.

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and comparing angler behavior and motivation across the urban-to-rural gradient in the U.S.

The COVID-19 pandemic provided an unanticipated opportunity to explore this urban-to-rural angler gradient. In 2020, COVID-19 interrupted individual and social behaviors and norms across the world. After the World Health Organization declared COVID-19 a pandemic on March 11, 2020, the U.S. began to implement federal travel bans and state- and county-wide stay-at-home orders to curtail the spread of COVID-19 (Centers for Disease Control and Prevention, n.d.). As a result, typical routines were disrupted as businesses, schools, and social events were shut down or postponed. Shutdowns forced people to engage in different or new activities that were compatible with social distancing recommendations (e.g., home quarantining, physical distancing, wearing masks in enclosed spaces). During this time, many outdoor activities increased in popularity (Taff et al., 2021), including fishing (Midway et al., 2021; Britton et al., 2023) and hunting (Chizinski et al., 2022; Danks et al., 2022), though increased recreation tended to occur locally (Chizinski et al., 2022; Danks et al., 2022; Rice et al., 2020).

Government-mandated preventative measures aimed at curtailing the spread of COVID-19 did not occur simultaneously across the United States. At the onset of the pandemic, there was high variation in COVID-19 case counts, particularly between urban and rural communities. Urban communities were often the first to feel the effects of COVID-19, had higher case counts, and as a result were subject to stricter safety restrictions (Oster et al., 2022; Paul et al., 2020). Matthews et al. (2021) found that metropolitan communities had nearly double the COVID-19 incidence rates (5.70 cases per 100,000 persons) as nonmetropolitan areas (2.73 cases per 100,000 persons) at the beginning of the pandemic by dividing the number of positive COVID-19 cases in a given county by the county population. Furthermore, a survey from April to October of 2020 found that rural community members were less concerned about risks surrounding the COVID-19 pandemic than their urban counterparts (Chauhan et al., 2021). Rural community members were generally less supportive of stay-at-home mandates and shutdowns and less likely to engage in preventative behaviors (Callaghan et al., 2021; Chauhan et al., 2021). Overall, differences in case counts along rural to urban gradients were reflected in attitudes surrounding the pandemic.

Investigations of the pandemic on anglers tend to treat anglers as a uniform population (Howarth et al., 2021 [in Canada]; Midway et al., 2021; Trudeau et al., 2022); however, anglers are a heterogenous group with different behavioral motivators (Arlinghaus et al., 2008 [in Germany]; Chipman and Helfrich, 1988; Fedler and Ditton, 1994; Schuett et al., 2010). Examining pandemic angling behaviors at a local level—e.g., U.S. counties—could reveal smaller-scale heterogeneity in how anglers perceived and responded to the pandemic. A recreational angling survey of 18,000 licensed anglers representing 10 states was conducted in summer 2020 (and published a year later; Midway et al., 2021) to understand broad fishing trends during the pandemic. From the survey, Midway et al. (2021) concluded that fresh- and saltwater anglers fished more during the pandemic than they did in typical years. The study presented here builds off this survey by combining the survey data with county-level population density and COVID-19 case counts. Specifically, we ask if, in the early pandemic (01 March 2020–31 May 2020), population density or COVID-19 cases per capita influenced 1) changes in license sales, 2) number of fishing trips, and 3) fishing motivations.

2. Methods

2.1. Data sources

In the summer of 2020, a 20-question probabilistic survey was emailed to 224,061 licensed recreational anglers in Arkansas, Connecticut, Florida, Iowa, Missouri, North Carolina, South Carolina, Texas, Utah, and Wyoming. Email contacts were randomly selected by participating states and the 19 closed and 1 open-ended questions were each optional. States from each region of the U.S. were selected so findings could reasonably be assumed to describe nationwide fishing trends and angler attitudes at the onset of the pandemic. A total of 17,983 surveys were completed, resulting in $n = 16{,}919$ usable surveys (based on respondent consent) for a minimum response rate of 8% (American Association for Public Opinion Research, 2016). For more information, see Midway et al. (2021) for details on Institutional Review Board (IRB) approval and survey design.

Survey-response data were joined with U.S. Census county-level population estimates (U.S. Census Bureau, 2021) and COVID-19 case-count data from New York Times (NYT) data repositories (The New York Times, 2021). We opted to use a continuous population density gradient over a categorical classification system to avoid information loss from converting fine-scale population densities to more broad-scale urban/rural classifications and to more accurately represent the gradient of population densities that exist in the U.S. that do not always fit neatly into discrete categories. We chose to use NYT data for ease of use (e.g., transparent, well-designed GitHub data repository easily queried through R), county-level resolution, and because these data were all sourced from state and local governments. Several studies have shown NYT COVID-19 data to be comparable to other prominent sources of COVID-19 case count data as well as state department of health data (Arneson et al., 2020; Miller et al., 2022; Wang et al., 2023). Based on coordinates recorded from anonymous respondent IP addresses, surveys were joined to county FIPS codes, and then joined to 2020 Census population estimate data by county. We assumed that respondent IP addresses were representative of respondents' counties of residence because of travel restrictions and reductions at that time. Population estimates for each county were divided by county area (sq km) to obtain population density metrics. The NYT case counts were aggregated to total case counts per county during the period of 01 March 2020–31 May 2020, which matched the date ranges for which survey respondents provided angling behavior. County FIPS codes were again used to link the joined survey and population data to aggregated NYT COVID-19 case count data. Total case counts were divided by county population estimates from the census, then multiplied by 100 to obtain COVID-19 case counts per 100 people for each county.

2.2. Data analysis

Survey data were analyzed in R (R Core Team, 2022) to understand how fishing license purchase behavior, fishing trip frequency, and angler motivation varied by population density and per capita COVID-19 case counts. Prior to modeling, potential correlation between per capita COVID-19 cases and population density was examined, and their correlation was low enough to avoid concerns with subsequent analyses (untransformed data: Pearson's correlation coefficient = 0.18; log-transformed data: Pearson's correlation coefficient = 0.37). To determine changes in license sales, an ordinal logistic regression model was used to examine different angler behaviors in relation to population density and COVID-19 cases per capita. Because survey responses followed a logical ordering of answers [e.g., *No purchase (decided not to purchase when I typically would), Delayed purchase, No change, Hastened purchase, New purchase (decided to purchase when I typically would not)*], we used the VGAM R package (Yee, 2022) to fit a proportional odds ordinal logistic regression model (Agresti, 2018) to the data, where $\mathrm{logit}(P(Y \le j))$ is the cumulative logit function, α_j is the y-intercept, β is the rate of change, and x is the explanatory variable:

$$logit(P(Y \le j)) = \alpha_j + \beta x, j = 1, \ldots, c-1 \quad (1)$$

To determine how overall number of fishing trips before and during the pandemic varied over gradients of population density and COVID-19 cases per capita, we used a Bayesian hierarchal model with fixed slope and intercept terms. Exploratory analyses involving an interaction term between COVID-19 cases per capita and population density did not yield a significant interaction, so we proceeded with modeling predictor variables as main effects in subsequent analyses. Because we hypothesized that anglers went on more fishing trips during the pandemic spring than in a typical spring, we subtracted individual responses for a typical spring from the same respondent's reported trips for spring of 2020 and used this difference as the response variable. We chose to use differenced fishing trips as our response variable to capture the change in angler behavior due to the pandemic. Because the pandemic disproportionately impacted some demographics (Centers for Disease Control and Prevention, 2023), we also examined changes in fishing frequency among demographic groups of age, gender, and income available from the source survey data. To do so, we fit a set of hierarchical models examining differenced fishing trips as a function of COVID-19 cases per capita and allowed intercepts and slopes to vary among demographic factors of age and income as random effect terms. We chose to model gender as an interactive fixed effect rather than a random effect because there were only two factor levels (Gelman and Hill, 2006). To reduce skew in the data, COVID-19 cases per capita and population density were log-transformed prior to being included in the Bayesian models. Uninformative priors were used for all models and models were allowed to run until they converged. We examined 95% credible intervals (CRIs) of Bayesian model output to assess significance of predictor variables and demographic groups, whereby significance was determined if 0 was not included in the 95% CRI. All Bayesian hierarchical models were performed with the jagsUI (Kellner, 2021) package in R and with JAGS

Table 1
Summary count and count statistics of predictor and response variables for 12324 surveys across 589 U.S. counties.

Group	Variable	Responses	Minimum	Maximum	Median
	COVID-19 cases per capita (per 100 people)	-	0.006	3.758	0.192
	Population density	-	0.374	1741.417	153.781
license purchases	No purchase	161	-	-	-
	Delayed purchase	454	-	-	-
	No change	10931	-	-	-
	Hastened purchase	360	-	-	-
	New purchase	357	-	-	-
Differenced fishing trips	Overall	11333	-50	49	0
	Female	2259	-50	49	0
	Male	8985	-50	48	0
	< 18	72	-26	47	1
	18–39	3551	-50	45	0
	40–59	5489	-49	49	0
	> 60	2210	-44	46	0
	<$30,000	562	-47	37	0
	$30,000–$49,000	1005	-45	44	0
	$50,000–$79,000	2159	-50	49	0
	>$79,000	6953	-50	47	0
Pandemic fishing motivations	Food	2154	-	-	-
	Sport	3491	-	-	-
	Nature	4561	-	-	-
	Social	3295	-	-	-
	Stress relief	3669	-	-	-
	Competition with friends	592	-	-	-
	Free time	1944	-	-	-
	Get away	2151	-	-	-
	Don't normally fish	65	-	-	-
Pre-pandemic fishing motivations	Food	3266	-	-	-
	Sport	5412	-	-	-
	Nature	6267	-	-	-
	Social	4712	-	-	-
	Stress relief	4819	-	-	-
	Competition with friends	1011	-	-	-
	Free time	2033	-	-	-
	Get away	2799	-	-	-
	Don't normally fish	47	-	-	-

software (Plummer, 2003). Note that gas prices and fishing regulations could not be incorporated into the models due to the absence of publicly available county-level data, despite these likely having an important role in determining fishing effort (see, for example, Carter et al., 2022).

Logistic regression models (Eq. 2) were used (R Core Team, 2022) to determine if fishing motivations before and during the pandemic were impacted by population density or COVID-19 cases per capita. In the model equation, $\mathrm{logit}(y)$ is the logit function, α is the y-intercept, β is the rate of change, and x is the explanatory variable:

$$logit(y) = \alpha + \beta x \tag{2}$$

Respondents were asked their motivations for fishing (*Food, Sport or Thrill, Nature or being outdoors, Social/Family bonding, Stress relief, Competition with friends, Free time, Get away, and Don't normally fish*) and responses were coded as a 1 if selected and a 0 if not. Again, COVID-19 cases per capita and population density were log-transformed prior to their inclusion in the models to reduce skew. See Table 1 for a summary of all variables used in the analyses.

3. Results

3.1. Fishing license purchase decisions

Anglers living in areas of higher COVID-19 cases per capita were more likely to hasten their license purchase or decide to purchase when they had not otherwise planned on purchasing a license during the early pandemic (Fig. 2). Ordinal logistic regression model results revealed that although population density had no significant impact, COVID-19 cases per capita were significantly associated withlicense purchases at the onset of the pandemic (likelihood ratio test statistic < 0.001). Increased COVID-19 cases per capita were associated with increased odds of anglers reporting *Hastened purchase* and *New purchase* (deciding to purchase when they otherwise would not) (hastened purchase odds ratio 19.992 [95% CI 18.587–21.503], new purchase odds ratio 41.502 [95% CI 37.914–45.429]). Odds of anglers reporting *No purchase*, *Delayed purchase*, and *No change* decreased as COVID-19 cases per capita increased (No purchase odds ratio 0.551 [95% CI 0.506–0.601], delayed purchase odds ratio 0.016 [95% CI 0.014–0.018], no change odds ratio 0.063 [95% CI 0.058–0.068]). Increased likelihood of angling activity predominantly occurred once COVID-19 cases reached a critical density of roughly two cases per 100 people (Fig. 2). Importantly, anglers living in areas in the top quartile of per capita COVID-19 cases during the early pandemic were 3.62 times more likely to hasten their license purchase, 4.57 times more likely to purchase a license when they otherwise would not, and 5 times less likely to delay or not purchase a license as compared to anglers living in areas in the bottom quartile of per capita COVID-19 cases. Nagelkerke's pseudo R-squared value was low (0.008), indicating poor fit (Menard, 2000); however, the results of the likelihood ratio test indicated that although a poor fit, the model was a significant improvement over the null model ($p < 0.001$).

3.2. Fishing trip frequency

Anglers living in areas of higher COVID-19 cases per capita went on significantly more fishing trips in the early pandemic than they would typically (Fig. 3). Results from the Bayesian analysis revealed that though population density had no effect, the number of fishing trips taken increased, on average, across the COVID-19 case gradient as compared to a typical spring ($\mu_\beta = 0.276$, 95% CRI = 0.116–0.441). Further analysis of this trend by demographic groups revealed no difference in the trend by gender but did yield differences within age and income groups (Table 2; Supplemental Figs. 1, 2, & 3). CRIs revealed COVID-19 cases had a significant, positive effect on fishing frequency in anglers aged ≥ 40 years and earning $\geq$\$50,000 (Age 40–59: $\mu_\beta = 0.250$, 95% CRI = 0.050–0.440; Age > 60: $\mu_\beta = 0.400$, 95% CRI = 0.130–0.720; (\$50,000 –\$79,000 : $\mu_\beta = 0.330$, 95% CRI = 0.070–0.650; > \$79,000 : $\mu_\beta = 0.220$, % CRI = 0.040–0.400). There was no effect of COVID-19 cases on fishing frequency in angler age groups <40 years and earning <\$50,000 in the early pandemic (Table 2; Supplemental Figs. 1, 2, & 3). Overall, anglers reported going on an average of 0.38 more trips when COVID-19 cases per capita increased by 25%.

3.3. Angler motivations

Angler motivation varied across gradients of COVID-19 cases per capita and population density before and during the early pandemic (Fig. 4; for nonsignificant trends as well as significant trends, see Supplemental Fig. 4). In areas of greater population densities, anglers were significantly more likely to report fishing for *sport*, *stress relief*, and *competition with friends* before the pandemic and *stress relief* and *competition with friends* during the early pandemic (Table 3). Specifically, for every one unit increase in population density, the odds of anglers fishing for *sport, stress relief,* and *competition with friends* increased by 4.73%, 4.98%, and 9.54%, respectively, before the pandemic. The odds of anglers fishing for *stress relief* and *competition with friends* increased by 3.57% and 8.95% for every one unit increase in population density during the pandemic. Anglers living in areas of greater COVID-19 cases per capita were more likely to report that they fished for *sport* and because they had *free time* and were less likely to report fishing for *food* (Table 3). For every one unit increase in COVID-19 cases per capita, the odds of anglers fishing for *sport* and because they had *free time* increased by 4.75% and 7.30%, while the odds of anglers fishing for *food* decreased by 7.80%. Nagelkerke's pseudo R-squared values for all models were low; however, *p*-values from likelihood ratio test results were significant for all significant models (Supplemental Table 1). Thus, fishing motivations varied among urban and rural anglers, and COVID-19 case counts influenced fishing motivations during the early pandemic.

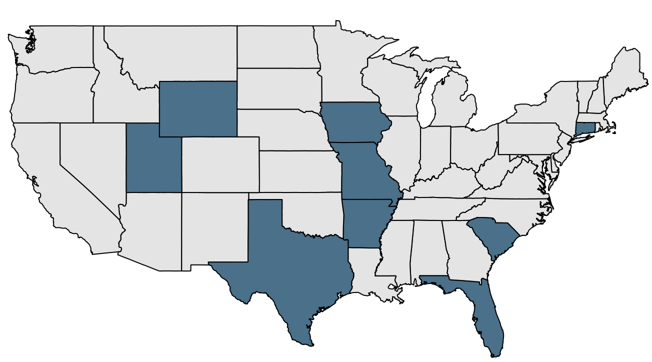

Fig. 1. Map of participating states shaded blue: Arkansas, Connecticut, Florida, Iowa, Missouri, North Carolina, South Carolina, Texas, Utah, and Wyoming.

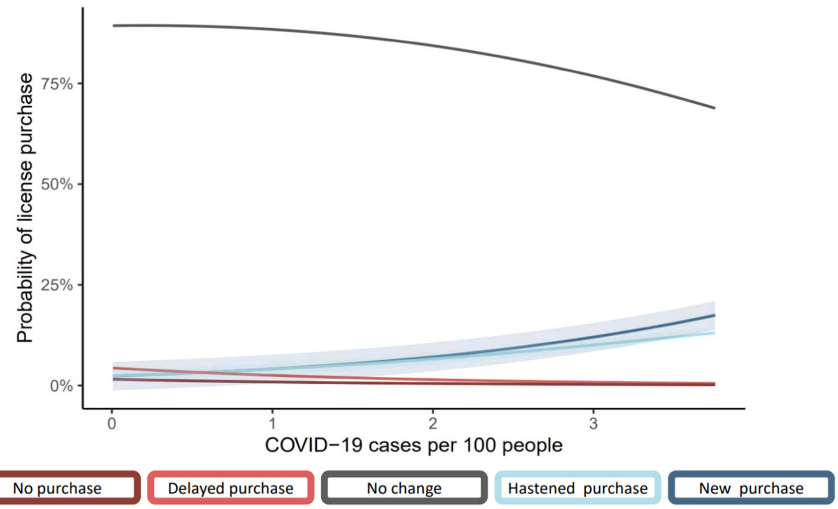

Fig. 2. Ordinal logistic regression curves showing the probability of purchasing a fishing license (compared to a typical year) for anglers living in areas of differing COVID-19 cases per 100 people during the early pandemic (01 March 2020–31 May 2020). In some cases, confidence intervals are visually indistinguishable from plotted lines.

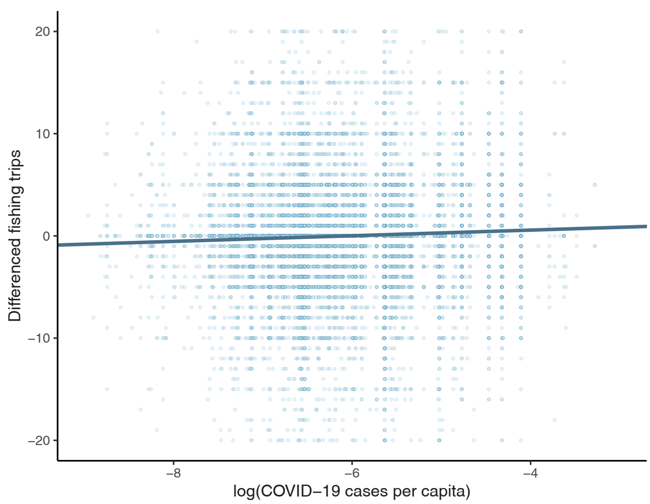

Fig. 3. Plotted slope and intercept estimates from Bayesian model showing differenced fishing trips (the number of trips taken in a typical spring subtracted from the number of trips taken in spring of 2020) for anglers living in areas of differing log-transformed COVID-19 cases per capita. The plot is scaled to focus on the majority of the data points.

Table 2
Results of Bayesian hierarchical models with interactive fixed effect (gender) and random effect (age, income) terms, as well as 95% credible intervals (CRIs) surrounding predicted slopes (μ_β). Terms in boldface text are considered significant (95% CRIs do not overlap zero).

	μ_β	Lower CRI	Upper CRI
Overall:			
log(COVID-19 cases)	**0.276**	**0.116**	**0.441**
log(Population density)	-0.036	-0.146	0.084
Age:			
< 18	0.890	-0.120	3.380
18–39	0.130	-0.120	0.340
40–59	**0.250**	**0.050**	**0.440**
> 60	**0.400**	**0.130**	**0.720**
Gender:			
Female	**0.371**	**0.059**	**0.719**
Male	**0.230**	**0.060**	**0.409**
Income:			
< $30,000	-0.160	-0.790	0.380
$30,000–$49,000	0.200	-0.200	0.520
$50,000–$79,000	**0.330**	**0.070**	**0.650**
>$79,000	**0.220**	**0.040**	**0.400**

4. Discussion

We used survey data to examine pandemic angling behavior across the urban to rural gradient by modeling survey responses over county-level population density and COVID-19 cases per capita. In aggregate, results suggest that per capita COVID-19 cases were more influential in driving angler behavior than was population density. COVID-19 case counts were found to be a significant driver of license sales, fishing frequency, and fishing motivation. Population density was a significant driver of fishing motivation before and during the early pandemic. However, when interpreting these results, it is important to consider the effects of omitted variables such as county-level fishing regulations and gas prices. Effort likely increases with decreased gas prices and less conservative fishing regulations (Carter et al., 2022). Thus, in addition to low levels of explained variation in our models, the presence of omitted variables may confound our results and we stress the need for caution when considering and interpreting the trends reported in this paper.

4.1. Temporal trends in angling

Our findings of increased angler recruitment (i.e., attraction of new individuals to recreational fishing) during the beginning of the pandemic are supported by broader temporal trends in fishing and hunting license sales. Similar studies document increased resident hunting permit sales in the U.S. in early 2020 (Chizinski et al., 2022; Danks et al., 2022). Moreover, the Wildlife and Sport Fish Restoration Program documents a 3.5% increase in fishing license sales for U.S. states and territories from 2019 to 2020 and a 10.3% increase from 2019 to 2021. Among the 10 states examined in this study, 6 experienced a rise in license sales from 2019 to 2020, while all states experienced increased sales from 2019 to 2021. This led to an average increase in fishing license sales of 3.2% from 2019 to 2020 and 11.5% from 2019 to 2021 across the study states (U.S. Fish and Wildlife Service, n.d.). The American Sportfishing Association tracks more detailed license sales data from 20–25 participating states in the U.S and documents increased fishing license sales were driven by spikes in resident license purchases. Non-resident purchases declined during this same period, indicating the importance of local recreation during the pandemic. License sales to female anglers and younger anglers saw the greatest percent increases in

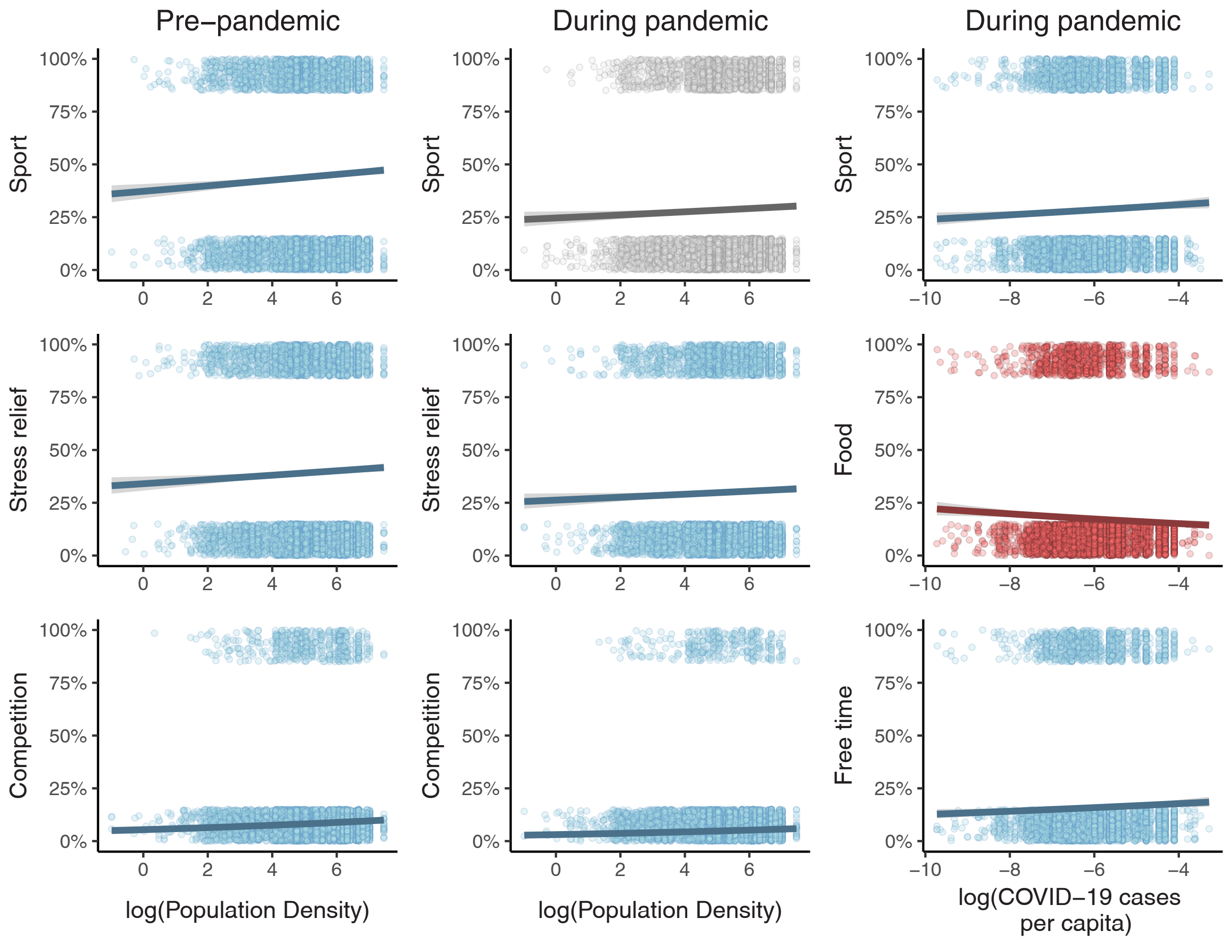

Fig. 4. Binomial regression plots showing the probability curves of *sport*, *stress relief*, and *competition* fishing motivations over log-transformed population density gradients before and during the early pandemic (01 March 2020–31 May 2020), as well as *food, free time*, and *sport* fishing motivations over log-transformed COVID-19 cases per capita gradients. Blue lines and points indicate a significant positive relationship, red lines and points indicate a significant negative relationship, and gray lines and points indicate a nonsignificant relationship. In some cases, confidence intervals are visually indistinguishable from plotted lines.

Table 3
Odds ratios and *p*-values for binomial logistic regression models predicting fishing motivations before and during the early pandemic (01 March 2020–31 May 2020). Odds ratios in boldface text are significant because their associated 95% confidence intervals exclude 1; *p*-values in boldface text are considered significant (<0.05).

Fishing motivation	Pre-pandemic	During early pandemic	
	log(Population density)	log(Population density)	log(COVID-19 cases per capita)
Food	OR = 1.019; *p* = 0.277	OR = 1.000; *p* = 0.991	**OR = 0.922; *p* = 0.004**
Sport or Thrill	**OR = 1.047; *p* = 0.003**	OR = 1.026; *p* = 0.138	**OR = 1.048; *p* = 0.047**
Nature or being outdoors	OR = 1.021; *p* = 0.186	OR = 0.999; *p* = 0.949	OR = 1.041; *p* = 0.067
Social/Family bonding	OR = 1.000; *p* = 0.994	OR = 0.983; *p* = 0.324	OR = 1.012; *p* = 0.652
Stress relief	**OR = 1.050; *p* = 0.002**	**OR = 1.036; *p* = 0.038**	OR = 0.999; *p* = 0.976
Competition with friends	**OR = 1.095; *p* = 0.002**	**OR = 1.090; *p* = 0.021**	OR = 1.020; *p* = 0.707
Free time	OR = 1.015; *p* = 0.487	OR = 0.994; *p* = 0.777	**OR = 1.073; *p* = 0.014**
Get away	OR = 1.007; *p* = 0.695	OR = 1.000; *p* = 0.980	OR = 1.043; *p* = 0.131
Don't normally fish	OR = 0.907; *p* = 0.407	OR = 1.062; *p* = 0.583	OR = 0.838; *p* = 0.240

2020 (American Sportfishing Association, 2023). These findings of increased recreational fishing are notable because the percentage of licensed anglers in the U.S. has generally declined nation-wide since 1990 (U.S. Fish and Wildlife Service, 2015), as angler demographics fail to keep pace with shifting U.S. demographics (Murdock et al., 2008).

Even so, the limited timeframe of analysis could potentially reflect temporal reallocation of fishing effort rather than a true one-year increase in effort. The cross-sectional survey design means observed trends are confined to the specific timeframe in which data were collected, and it is possible that subsequent dynamics may have influenced trends reported in this study. For instance, marine recreational fishing effort monitoring was largely uninterrupted in 2020 and the Marine Recreational Information Program (MRIP) reported comparable total fishing efforts in 2020 to previous years (National Marine Fisheries Service, 2022), while Midway and Miller (2023) reported monthly increases over 100% for the northern Gulf of Mexico. While freshwater recreational fishing effort monitoring faced more disruptions, it is possible that, as with marine recreational fishing effort, the spike in fishing trips seen in the early pandemic balanced out, resulting in overall fishing effort in 2020 that paralleled other years.

4.2. Demographic factors

Pandemic changes in fishing frequency varied by socio-economic factors, likely reflecting differential impacts of the pandemic across demographics (e.g., race/ethnicity & population density (Iyanda et al., 2022); race and population density (Sood and Sood, 2021); gender (Danielsen et al., 2022); race/ethnicity (Moore et al., 2020); vulnerable persons/chronic disease (Embury et al., 2022); population density, preexisting risk factors, & race (Paul et al., 2020); occupation/frontline workers (Do and Frank, 2021)). Though there was an overall trend of increased fishing frequency with increasing case counts in these survey data, the direction and magnitude of this trend varied by socio-economic factors of age and income level. Specifically, the trend of increased fishing frequency was driven by anglers aged ≥40 years and earning ≥$50,000 . Though nonsignificant, individuals among the lowest income levels were the only demographic group to report a trend of declining fishing frequency with increasing cases (Supplemental Fig. 1). This may be due to the increased reliance upon "essential and frontline workers" during the pandemic, many of whom work in lower income brackets (Blau et al., 2022). As a result, essential and frontline workers may have had less free time during the pandemic compared to other groups (Office for National Statistics, 2020 [in Great Britain]). Even so, overall increases in fishing frequency occurred at the same time people were reducing travel distance and frequency (Bureau of Transportation Statistics, 2023), suggesting social "fish-tancing" was an accessible, localized activity for many during the early pandemic.

4.3. Fishing motivations

In addition to increasing angling activity, the COVID-19 pandemic also altered angler motivations for fishing in spring of 2020. Specifically, anglers in areas of greater case counts were less likely to report fishing for *food* and more likely to report fishing for *sport* and because they had *free time*. The latter is most likely a direct byproduct of pandemic cancelations in heavily impacted areas (U.S. Bureau of Labor Statistics, 2021). It is unclear why fishing for *food* declined in more heavily impacted areas, especially given that food insecurity increased during the early pandemic (Niles et al., 2020). Possibly, lower income anglers who tend to supplement their diet by fishing were kept busy with "frontline and essential jobs" (Blau et al., 2022; Burger, 2002; von Stackelberg et al., 2017). Other factors such as consumption advisories and altered angler priorities and demographics may also have influenced this trend during the early pandemic (American Fisheries Society, 2022; Midway et al., 2021; Tilden et al., 1997). Examinations of angler motivations add to the growing body of literature that urban and rural anglers have different motivations for fishing (Arlinghaus et al., 2008; Hutt and Neal, 2010). While fishing for *sport* was only positively correlated with population density before the pandemic, *stress relief* and *competition among friends* were positively correlated with population density both before and during the early pandemic. We emphasize the importance of angling for stress reduction, particularly for urban anglers, was consistent through both time periods.

4.4. Study limitations

There are a few important limitations in this study that are worth discussing. This study relies on self-reported survey data, which can be biased due to rounding, recall problems, and nonresponse bias. The relatively low response rate could be due to the broad, external nature of the online survey and the timing of its distribution during the early pandemic when there were numerous disruptions and uncertainties. Indeed, web-based surveys are associated with lower response rates and other studies that conducted surveys assessing outdoor recreation during the early pandemic have similarly low response rates (Blumenberg and Barros, 2018; Rice et al., 2020). Additionally, government regulations and angler behaviors varied widely within and among states and some states not represented in the survey may have had different responses to the pandemic. Even so, Paradis et al. (2021) found that only 3 states—Washington, California, and Maryland— suspended some or all fishing in the early pandemic. Thus, states with more restrictive responses to the pandemic tended to be the exception rather than the rule. Ultimately, these analyses are subject to the same biases discussed in Midway et al. (2021) reporting on the survey (e.g., self-reported survey data, low response rate, and non-response bias).

Limitations unique to our study come from population data and COVID-19 case count data. For example, testing shortages at the onset of the pandemic and the prevalence of asymptomatic cases mean that COVID-19 case count data are underestimated, with greater underestimates in areas of larger case counts. Ordinal and logistic regression models exhibited relatively poor fit, and, in the Bayesian models, data were highly variable with substantial increases and decreases in the number of fishing trips taken (± 50 trips). It is possible that the high variation in individuals' response to the pandemic could, in part, be because this survey was done at a time when individuals were still grappling with how to respond to the novel pandemic event. Other pandemic angling studies document an initial lag period during spring of 2020 before later increases in angling activity (Bunt and Jacobson, 2022; Howarth et al., 2021). Moreover, a study examining pandemic fishing effort in recreational marine fisheries also records highly variable behavioral responses, concluding that the heterogenous data reflect the complex relationships between the pandemic event and behavioral responses (Apriesnig and Thompson, 2021). Certainly, the pandemic altered angling behavior, but responses were highly individualistic and potentially influenced by factors outside the scope of this study. Changing gas prices, local and state fishing regulations, and individual risk factors and employment are some examples of factors unaccounted for here that may have impacted angler behaviors and decision-making at this time. The relatively high levels of unexplained variation in the models is likely a reflection of the difficulty of modeling a dynamic and multifaceted situation such as the impact of the COVID-19 pandemic on human behavior.

4.5. Conclusions

Recreational angling remains one of the most popular outdoor recreation activities behind only running and hiking, and 2020 saw record numbers of anglers (American Sportfishing Association, 2023; Outdoor Foundation, 2022). This study provides evidence that angler recruitment and fishing frequency increased with COVID-19 cases during the early pandemic. Additionally, we document that fishing motivations varied along the urban to rural gradient before and during the early pandemic. Findings from this and other surveys indicate increases in recreational fishing may have been driven, in part, by increased free time (American Fisheries Society, 2022). Management efforts can focus on maintaining resilient, accessible fisheries during times of stress because recreational angling is an important stress reduction activity (Karpiński and Skrzypczak, 2022; Midway et al., 2021). Additionally, because the pandemic stimulated angler recruitment, managers can examine ways to prioritize retaining and reactivating pandemic anglers (American Fisheries Society, 2021). Furthermore, managers can develop creel surveys aimed at understanding motivations and preferences of newly recruited anglers, helping managers to ensure these individuals continue to engage in the sport and support conservation efforts through license sales, fees, and other funding mechanisms.

Declaration of Competing Interest

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

Data Availability

See Midway et al. (2021) for survey data. For privacy reasons, some survey data was withheld prior to publishing the data. All other data are publicly available. Code is available at https://github.com/aluciakaz/Pandemic-Angling.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.fishres.2024.107021.

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