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Influence of anglers' specializations on catch, harvest, and bycatch of targeted taxa

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ABSTRACT

Fishery managers often use catch per unit effort (CPUE) of a given taxon derived from a group of anglers, those that sought said taxon, to evaluate fishery objectives because managers assume CPUE for this group of anglers is most sensitive to changes in fish taxon density. Further, likelihood of harvest may differ for sought and non-sought taxa if taxon sought is a defining characteristic of anglers' attitude toward harvest. We predicted that taxon-specific catch across parties and reservoirs would be influenced by targeted taxon after controlling for number of anglers in a party and time spent fishing (combine to quantify fishing effort of party); we also predicted similar trends for taxon-specific harvest. We used creel-survey data collected from anglers that varied in taxon targeted, from generalists (targeting "anything" [no primary target taxa, but rather targeting all fishes]) to target specialists (e.g., anglers targeting largemouth bass *Micropterus salmoides*) in 19 Nebraska reservoirs during 2009–2011 to test our predictions. Taxon-specific catch and harvest were, in general, positively related to fishing effort. More importantly, we observed differences of catch and harvest among anglers grouped by taxon targeted for each of the eight taxa assessed. Anglers targeting a specific taxon had the greatest catch for that taxon and anglers targeting anything typically had the second highest catch for that taxon. In addition, anglers tended to catch more of closely related taxa and of taxa commonly targeted with similar fishing techniques. We encourage managers to consider taxon-specific objectives of target and non-target catch and harvest.

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1. Introduction

There are suites of anglers targeting various groups of taxa (herein taxa targeting groups) during any given time at a waterbody. Further, there is a suite of anglers for which seeking a specific taxon is not a motivation to fish (Chizinski et al., 2014b), and this segment can compose a large percentage of total angling effort (Chizinski et al., 2014a, 2014b). Awareness that the influence of recreational fishing extends beyond the simple, angler-taxa targeted relationship is increasing (Beardmore et al., 2015; Cooke and Cowx, 2004, 2006; Lewin et al., 2006). The influence of fishing on targeted taxa is well known, which includes decreases in abundances of targeted taxa, changes in age and size structures of targeted taxa, and changes in fish community composition (Blaber et al., 2000). Anglers tend to prefer certain taxa because of their value for food and angling challenge (Lewin et al., 2006).

Fishery managers often group anglers based on taxon targeted (Malvestuto, 1996; Newcomb, 1992) to evaluate size selectivity in catch (Miranda and Dorr, 2000), to determine the effectiveness of standardized sampling to predict angler catch (Isbell and Rawson, 1989), and to monitor shifts in angler behavior following establishment of an invasive taxon (Coelle et al., 1987) or implementations of new regulations (Hale et al., 1999; Johnston et al., 2011; Stone and Lott, 2002). Fishery managers often limit data used to evaluate catch-rate objectives for a sportfish to a subset that only includes catch by anglers that targeted the taxon (e.g., Miranda, 2005; Stephens and MacCall, 2004) likely because managers assume catch rates are most sensitive to changes in taxon density for this group of anglers. However, this assumption has not been tested, and though catch rates are often positively correlated with fish density (Buynak and Mitchell, 1993; Engstrom-Heg, 1986; Newby et al., 2000; Olson, 1958), there are several well-illustrated

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Table 1
Physical characteristics of reservoirs and years anglers were interviewed.

Reservoir	Latitude (N)	Longitude (W)	Surface area (ha)	Years surveyed
Bluestem Lake	40.633831°	−96.796253°	132	2010
Branched Oak Lake	40.972539°	−96.863604°	728	2009–2010
Conestoga Lake	40.766403°	−96.850289°	93	2009
Cottontail Lake	40.647234°	−96.765408°	12	2010
Enders Reservoir	40.437152°	−101.538343°	500	2010–2011
Harlan County Reservoir	40.057313°	−99.272493°	5544	2009–2011
Holmes Lake	40.781431°	−96.633498°	40	2009
Lewis and Clark Lake	42.852479°	−97.603113°	12,550	2009–2011
Medicine Creek Reservoir	40.399800°	−100.231497°	642	2010–2011
Merganser Lake	40.602544°	−96.854616°	17	2010
Merritt Reservoir	42.627675°	−100.871769°	1093	2009–2011
Pawnee Lake	40.842609°	−96.869964°	300	2009–2010
Red Cedar Lake	41.163304°	−96.875188°	20	2009
Red Willow Reservoir	40.358777°	−100.671773°	240	2010–2011
Sherman Reservoir	41.302863°	−98.885985°	1174	2009–2011
Stagecoach Lake	40.603445°	−96.637604°	79	2009–2010
Swanson Reservoir	40.161328°	−101.068364°	1657	2010–2011
Timber Point Lake	41.196186°	−96.977591°	11	2009
Wildwood Lake	41.034361°	−96.838234°	42	2010–2011

examples in which catch rates are not linearly related with fish density (Gaertner and Dreyfus-Leon, 2004; Harley et al., 2001; Tsuboi and Endou, 2008; VanDeValk et al., 2005; Ward et al., 2013a).

A variety of aspects influence the decision on which taxa to target. The most influential, within the context of the fishing trip (Beardmore et al., 2011), is perhaps anglers' motives. For example, anglers may target a particular taxon to satisfy different catch-related attributes, such as targeting harvestable-sized channel catfish *Ictalurus punctatus* to eat on one trip and targeting trophy-sized muskellunge *Esox masquinongy* to test their fishing skill on the next trip. Further, catchability of fish likely differ among habitat types; the use of littoral zones by bluegill *Lepomis macrochirus* and largemouth bass *Micropterus salmoides* often shifts with size (Wanjala et al., 1986; Werner and Hall, 1988). Therefore, anglers may alter approaches used to target different taxa to accomplish specific goals during a fishing trip. For example, if catch of bluegill is greater in the littoral zone, then anglers may choose to target bluegill from the bank. Taxon preferences of anglers are linked to harvest preferences (Reitz and Travnichek, 2006; Wilde and Ditton, 1991), but it is unknown whether the likelihood of harvest on a given trip is related to taxon targeted during that trip. Differences in likelihood of harvest between targeted and non-targeted taxa are expected if taxon targeted on a given day is a defining characteristic of anglers' attitude toward harvest. For example, an angler targeting walleye (a harvest-orientated species) on a given trip may be more willing to harvest other incidentally caught taxa (e.g., largemouth bass and white bass *Morone chrysops*) during a trip. In contrast, an angler targeting largemouth bass (a catch-and-release-orientated species) may be unwilling to harvest other incidentally caught taxa (e.g., walleye *Sander vitreus* and white bass) during a trip.

The purpose of this study was to quantify taxon-specific catch and harvest for anglers targeting various fish taxon. We examined catch and harvest of eight fish groups (six species, one hybrid, and two species combined; hereafter taxon) for anglers targeting "anything" (no primary target taxon, but rather targeting all fishes), bluegill, channel catfish, common carp *Cyprinus carpio*, crappie (black crappie *Pomoxis nigromaculatus* and white crappie *P. annularis* combined), hybrid striped bass *Morone chrysops* × *M. saxatilis*, largemouth bass, walleye, and white bass in 19 Nebraska reservoirs during 2009–2011. Specifically, we predicted that taxon-specific catch across reservoirs (random categorical variable) would be influenced by targeted taxon (categorical variable of interest) after controlling for number of anglers in a party and time spent fishing (these combine to form effort); we also predicted similar trends for taxon-specific harvest.

2. Materials and methods

2.1. Angler interviews

We interviewed anglers in person during 2009–2011 at 19 reservoirs throughout Nebraska (Table 1). We use a stratified multistage probability sampling regime (Malvestuto 1996) to determine days of interviews. We completed surveys on 10, 12, 20, or 24 days per month at each reservoir depending on logistics and surface area. As time and duration of creel shifts varied among reservoirs, we only included interviews completed between sunrise and sunset and between 01 April and 31 October in the analyses. Only data from complete-trip interviews were included in this assessment. One angler, the representative, completed the survey for all members of the party (i.e., a group of individuals travelling together for the purpose of fishing); thus, data were collected at the party level. During the interview, creel clerks identified and counted harvested fish. Creel clerks recorded, as specified by anglers, the number of anglers in the party, the time spent fishing, and the numbers and taxa of released fish. Angler catch is the sum of fish harvested and fish released.

2.2. Data analysis

For this analysis, we considered a reservoir to have sufficient incidence of anglers targeting a taxon if there were 50 or more interviews of angler-parties that targeted a specific taxon. Further, we only considered taxon for which there were five or more reservoirs with the aforementioned criteria. We were interested in a broad description of catch and harvest characteristics; thus, we combined data across reservoirs and years for this analysis. Anglers targeting anything, bluegill, channel catfish, common carp, crappie, hybrid striped bass, largemouth bass, walleye, and white bass met our requirements for inclusion in this analysis (Table 2).

We tested for differences in taxon-specific catch and harvest among angler groups by modelling catch and harvest with mixed-effects models. The taxon-specific number of fish caught, or harvested, was a function of number of anglers, time spent fishing (h), taxon targeted, and angler type (bank or boat) (all fixed effects) and reservoir (random effect). We evaluated three distributions (Poisson, negative binomial, and zero-inflated Poisson) for catch and harvest of each taxon (Maunder and Punt, 2004; Venables and Dichmont, 2004), and identified the best fitting model with a log-likelihood test using the bblme package (Bolker et al., 2014) in R (R Development Core Team, 2014). This approach allowed us to

Table 2
General characteristics of angler parties within each group.

Taxon Targeted	Number of parties interviewed	Number of reservoirs	Median (range) party size	Median (range) fishing time (h)	Percentage of interviewed parties that: Fished from bank	Caught a fish	Caught a fish in taxon targeted	Harvested a fish	Harvested a fish in taxon targeted
Anything (all taxa)	2006	19	2 (1–9)	3.3 (0.5–8.1)	34	67	67	29	29
Bluegill	89	15	2 (1–6)	2.8 (0.6–7.9)	26	94	88	53	47
Channel catfish	1155	19	2 (1–11)	4.3 (0.5–8.9)	27	79	71	54	52
Common carp	64	8	2 (1–7)	3.1 (0.7–6.9)	23	56	53	36	36
Crappie[a]	564	15	2 (1–6)	3.3 (0.6–8.0)	49	78	70	51	49
Hybrid striped bass	197	7	2 (1–6)	3.8 (0.7–8.1)	58	74	40	27	20
Largemouth bass	404	19	2 (1–6)	3.9 (0.6–8.5)	42	82	73	11	7
Walleye	4800	13	2 (1–11)	4.8 (0.5–9.2)	11	80	60	47	38
White bass	1806	9	2 (1–10)	3.8 (0.5–6.0)	14	75	66	53	47

[a] Black crappie and white crappie combined.

directly assess the catch and harvest among taxon targeting groups without the confounding effect of differences in effort by keeping all other parameters constant except the parameter of interest. The reference level of the taxon sought parameter was set to be the same as the taxon being modeled for each taxon (e.g., reference level for the bluegill harvest model was anglers targeting bluegill). Anglers that targeted common carp, hybrid striped bass and largemouth bass were excluded from some of the catch and harvest models because sample sizes were too small to estimate parameters. Modeling was accomplished with the glmmADMB package (Skaug et al., 2014) in R. We generated model predictions (fixed effects only) of absolute catch of each taxon sought by the corresponding angler group as a function of party effort (h), party size and angler type (bank or boat). For predictions of absolute catch among varying effort (one to eight h), we held party size constant at three individuals and for predictions of absolute catch among varying party size (one to six individuals), we held party effort constant at three hours.

3. Results

There were 11,085 interviews included in this analysis, representing information collected from 24,166 anglers (Table 2). Surveyed angler-parties caught 5606 bluegill, 7692 channel catfish, 648 common carp, 8036 crappie, 1400 hybrid striped bass, 3975 largemouth bass, 19,201 walleye, and 21,373 white bass. Surveyed angler-parties harvested 1804 bluegill, 4228 channel catfish, 151 common carp, 3670 crappie, 462 hybrid striped bass, 197 largemouth bass, 6033 walleye, and 12,006 white bass.

Most of the surveyed angler-parties caught at least one individual of the species targeted during their fishing trip, with the greatest percentage for angler-parties targeting largemouth bass and the least percentage for angler-parties targeting common carp (Table 2). Median catch per unit effort (CPUE; catch of all taxa combined within taxon-targeted group) ranged from 0.18 to 2.06 fish per hour per angler, with the highest (median) catch rate for angler-parties targeting bluegill and the lowest catch rate for angler-parties targeting common carp (Fig. 1). In addition, most of the surveyed angler-parties harvested at least one individual of the species targeted during their fishing trip, with the greatest percentage for angler-parties targeting channel catfish and the least percentage for angler-parties targeting largemouth bass (Table 2). Median harvest per unit effort (HPUE; harvest of all species combined within taxon-targeted group) ranged from 0.00 to 0.12 fish per hour per angler, with the highest (median) harvest rate for angler-parties targeting channel catfish and the lowest harvest rate for angler-parties targeting anything, common carp, hybrid striped bass, largemouth bass, and walleye (Fig. 1).

The CPUE and HPUE of targeted species were greater than CPUEs and HPUEs of non-targeted species, respectively, for all taxon targeted except common carp (Fig. 2). Angler-parties targeting bluegill had the greatest CPUE of taxon targeted, whereas anglers targeting hybrid striped bass had the least CPUE of taxon targeted. It was evident for all taxon targeted that anglers caught and harvested taxa additional to the taxon targeted. Angler-parties targeting anything were unique as there was not a taxon targeted nor was there a taxon

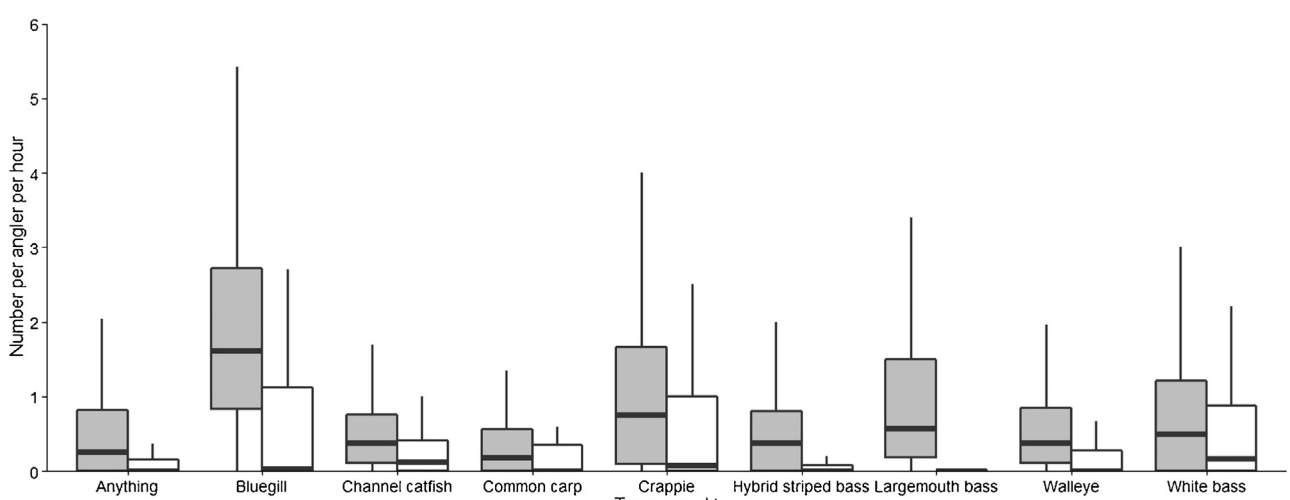

Fig. 1. Boxplots of the number of fish (all taxa combined) caught per hour per angler (gray box) and number of fish harvested per hour per angler (white box) for each angler group (taxa targeted). The upper and lower box edges correspond to the first and third quartiles and whiskers extend from the box edge to the farthest value within 1.5 times the interquartile range (McGill et al., 1978).

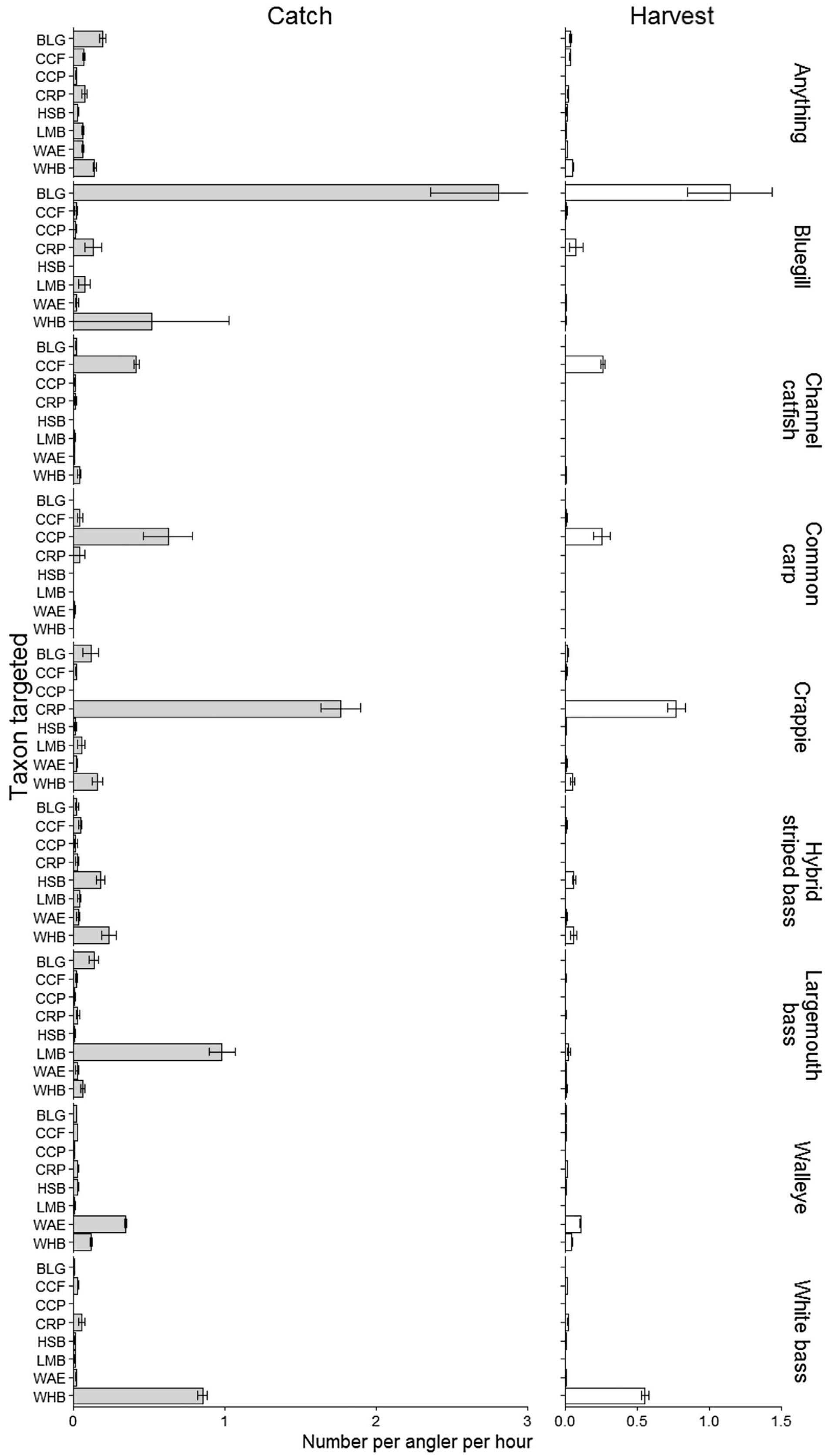

Fig. 2. Mean ± SE catch per hour per angler (left panels) and harvest per hour per angler (right panels) for taxa caught by each angler group (taxa targeted). Taxa codes are BLG = bluegill, CCF = channel catfish, CCP = common carp, CRP = crappie spp., HSB = hybrid striped bass, LMB = largemouth bass, WAE = walleye, and WHB = white bass.

for which CPUE or HPUE was greatest (Fig. 2); this group of anglers also had the smallest ranges in CPUE and HPUE across taxa.

The most appropriate models for absolute catch and absolute harvest of bluegill, channel catfish, common carp, crappie, hybrid striped bass, largemouth bass, walleye, and white bass used a Poisson distribution, except the most appropriate model for harvest of common carp used a zero-inflated Poisson distribution (Appendix A–H). Numbers of fish caught and harvested increased with both party size and fishing time for all taxa except common carp (neither catch nor harvest increased with party size), crappie (neither increased with party size) and largemouth bass (catch decreased with party size) (Fig. 3). Absolute catch and absolute harvest varied by taxon targeted, with greatest catch and harvest for the taxon targeted. The group of anglers that generally had the second highest catch of a taxon (relative to anglers that targeted that taxon) targeted anything; the exceptions were for crappie and walleye. Anglers that fished from the bank caught and harvested more bluegill, common carp, crappie, hybrid striped bass and largemouth bass (harvest only) relative to anglers that fished from boats, whereas anglers that fished from boats caught and harvested more channel catfish, walleye, and white bass relative to anglers that fished from the bank (Fig. 3).

4. Discussion

As expected, taxon-specific catch and harvest increased with time spent angling. Though most catch increased with party size, catch for three taxa did not follow that trend. For the common carp and crappie catch models, there was no relationship between party size and number of fish caught when all else was kept constant; that is, catch was best described at the party level without consideration of party attributes, perhaps evidence of compensatory interactions among anglers within a party. For the largemouth bass model, the number caught decreased with increasing party size, which is likely evidence of some competitive interference among anglers within a party. Specifically, model predictions suggest that among anglers targeting largemouth bass there was a ~5% decrease in the number caught per hour for each additional angler in the party. Similarly, Miranda (2005) observed decreased catch rates of black bass with increasing party size. The differences we observed among taxa may be related to modes of fishing for each target taxon. Taxon that are in greater abundance in a waterbody or tend to be caught by moving greater distances in open water (e.g., white bass or walleye) may not experience a localized depletion of individuals with more anglers in a party because the moving boat is constantly exposing the anglers to new fish. Alternatively, angler parties focusing on structures along the shore (e.g., targeting largemouth bass) could be competing for a more restricted number of fish and thus might experience depletion of those fish at a greater rate (Miranda, 2005). Additionally, it is possible that angling parties with a greater number of individuals in the party may have anglers with lower skill level or different priorities for recreation. Angler parties with different composition have different priorities in their site selection (Hunt and Ditton, 1997), which could be linked to decreased catch (Ward et al., 2013a). For example, parties composed of family and friends put a greater priority than parties composed of a single angler on selection of sites with greater recreational opportunities, which could be related to factors associated with decreased catch (Graham and Cooke, 2008).

Anglers vary in skill level (Bryan, 1977) and behavior (Ward et al., 2013b), which influences anglers' catch and harvest, and ultimately total absolute catch and harvest, for targeted and non-targeted taxon (Bloom, 2013). We observed differences of catch and harvest among anglers grouped by taxon targeted for each of the eight taxon assessed. Anglers targeting a specific taxon had the greatest catch for that taxon, and anglers targeting anything typically had the second greatest catch of a given taxon. In addition, anglers tended to catch more of closely related taxon and of taxon within similar feeding guilds (Elliott et al., 2007; Jackson et al., 2001) that are commonly targeted with similar fishing techniques. For example, the second highest catch for hybrid striped bass (pelagic predator) occurred for anglers that targeted white bass (pelagic predator), whereas the second highest catch for common carp (benthic omnivore) occurred for anglers that targeted channel catfish (benthic omnivore). Patterns observed for harvest were similar to patterns observed for catch, not surprising given that catch is a prerequisite for harvest. Our analysis provides clear evidence that recreational anglers in inland reservoirs are most efficient at catching and harvesting the taxon they target during a specific fishing trip. Our analysis also provides evidence that recreational anglers targeting anything in inland reservoirs are quite efficient at catching and harvesting the taxa we assessed.

Anglers target different taxon to accomplish different recreational goals (Beardmore et al., 2011; Wilde and Ditton, 1991). Anglers also will identify a preferred fish taxon and will have similar recreational goals and attitudes as other anglers that prefer that taxon (Beardmore et al., 2011; Wilde and Ditton, 1991). Anglers can, and often do, temporally change the taxon they target to accomplish different goals. As such, memberships in the angler groups assessed herein may not be mutually exclusive. That is, an interviewed angler could have identified walleye as the taxon targeted on a trip during April and white bass as the taxon targeted on a trip during June. Even so, we expected that presentation styles, terminal tackle used, motivations, and perhaps number of anglers in a party and time spent fishing would differ between these two trips, which would lead to differences in catch and harvest for targeted and non-targeted taxon. Knowledge of angler-group composition across temporal and spatial scales is needed to better understand what proportion of anglers belong to multiple groups and how multiple memberships influence taxon-specific catch and harvest. For example, regional differences in composition of novice and specialist (Bryan, 1977) anglers could lead to regional differences in taxon-targeted catch and harvest if differences exist in likelihoods that novices and specialists change taxa targeted among fishing trips.

Managers and scientists often organize anglers into groups of individuals with similar attitudes, preferences and fishing practices (Beardmore et al., 2011, 2015). Conventional wisdom that groups anglers by taxon targeted dictates catch and associated harvest of a taxon will be greatest for anglers that target the taxon, and will be the truest measure of changes in taxon density. However, many anglers, when asked, would not identify a taxon targeted. Managers and scientists frequently encounter this situation during surveys of anglers (Hale et al., 1999). Unfortunately, managers and scientists often exclude the group of anglers targeting anything from taxon-specific analyses of angler effort, catch and harvest, and attitudes and opinions. There may be a fundamental difference between anglers targeting anything (i.e., all fishes targeted) and anglers targeting a specific taxon. Anglers targeting anything may be comprised of a diversity of specialists (a sample of parties from several angler groups), comprised of generalists (compared to other angler groups each comprised of specialists), or comprised of a combination of both. If this group is comprised of casual or occasional anglers (Bryan, 1977; McFarlane, 1994), then exclusion from taxon-specific analysis likely results in under-estimation of angler effort directed toward a taxon and over-estimation of catch and harvest of that taxon. Similarly, if this group is comprised of generalists, then exclusion from analyses likely results in biases especially if this group composes at least 10% of anglers at a given reservoir. Effort by anglers targeting anything can exceed effort targeted at a single taxon (e.g., Chizinski et al., 2014a, 2014b). Examination of catch

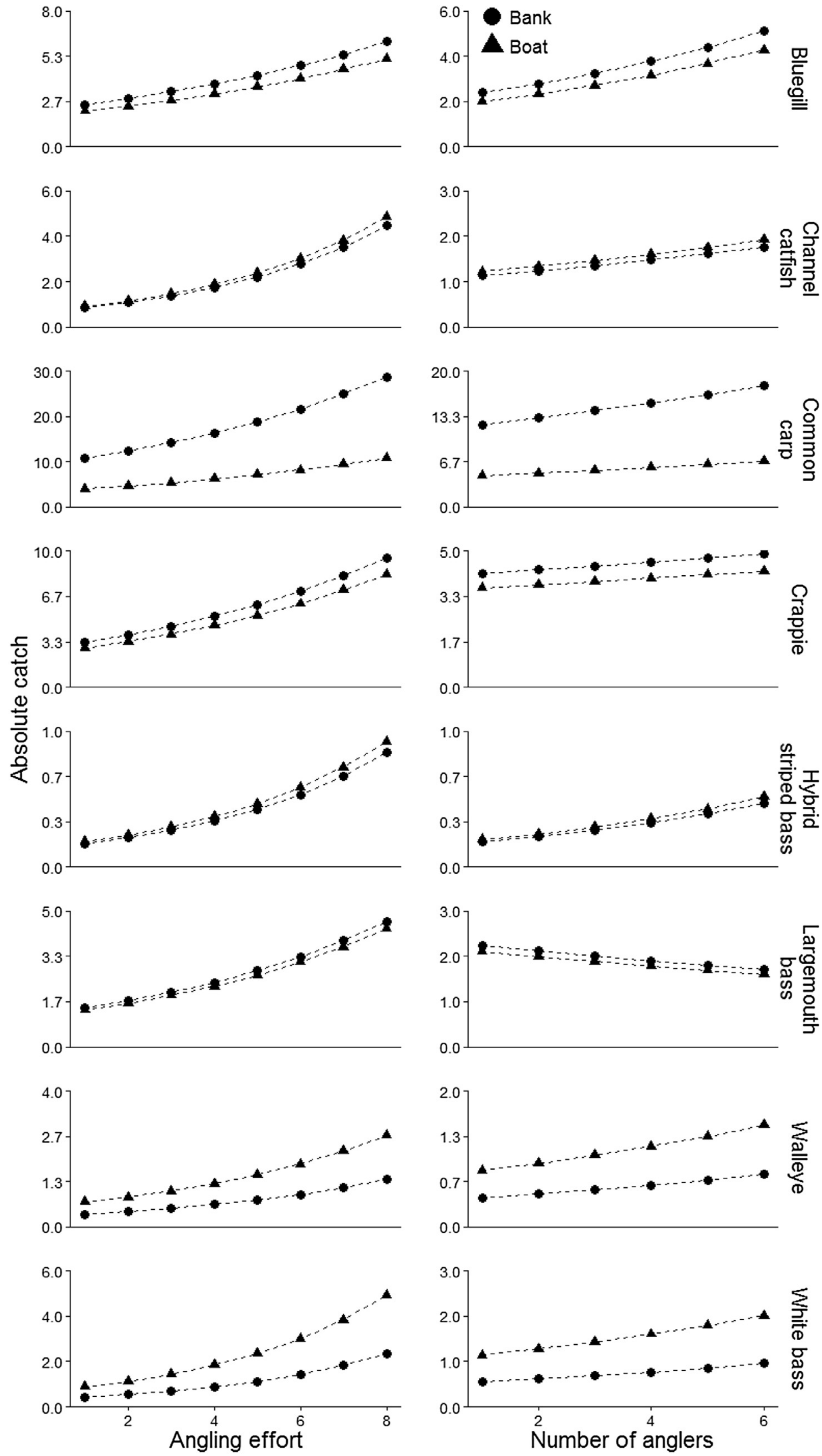

Fig. 3. Predicted absolute catch (taxon targeted) for each angler group (taxa targeted) as a function of party effort (h; left panels), party size (right panels) and angler type (bank or boat). Model predictions were based on fixed effects only and used party size of three anglers (left panel) and party effort of three hours (right panel) for predictions.

and harvest composition at the party level would likely provide additional insights about the composition of this group of anglers. If catch and harvest of most parties in this group were dominated by a single taxon (but different taxon across parties), then it might be appropriate to *a posteriori* classify those parties that caught the taxon of interest to the respective taxon-targeted group.

Different anglers seek different fishing experiences, likely to satisfy multidimensional desires (Beardmore et al., 2015; Kuentzel and McDonald, 1992) associated with level of recreational specialization (Chipman and Helfrich, 1988; Fisher, 1997) within the context of life's circumstances (Kuentzel and Heberlein, 2008). Responses to attitudinal questions toward trophy fish and fish to eat is influenced by mode of access (bank or boat), with trophy fish being more important to boat anglers and fish to eat being more important to bank anglers (Hudgins, 1984). Even so, it is unknown whether or not angler motives shift with taxon targeted for mode of access (bank or boat) to a fishery (Fedler and Ditton, 1994). We observed some expected patterns in catch and harvest among the two modes of access assessed. Catch and harvest for bluegill, common carp, and crappie were greater for bank anglers, whereas catch and harvest for channel catfish, walleye and white bass were greater for boat anglers. We also observed some surprising patterns in catch and harvest among the two modes of access. Holding all other parameters constant, catch and harvest of hybrid striped bass were greater for bank anglers, and catch of largemouth bass was similar for bank and boat anglers, yet harvest of largemouth bass was greater for bank anglers. Availability and catchability of taxon likely differ among habitat types, especially habitats typical within littoral and limnetic zones. Use of littoral and limnetic zones by bluegill and largemouth bass often shifts with fish size (Wanjala et al., 1986; Werner and Hall, 1988). Bank anglers are often confined more than boat anglers in their choice of habitat to fish; bank anglers can only fish littoral habitat (with a possible few exceptions), whereas boat anglers can choose to fish littoral or limnetic or both zones. Further, bank anglers are often confined more than boat anglers in their choice of fishing technique; it is extremely difficult and hence unlikely that a bank angler will troll a lure—a common technique for catching fish from a boat.

There are numerous caveats to the work presented herein. First, we generalized results across reservoirs with differing fish communities (though we did include reservoir as a random variable in all models), which may have masked some reservoir-specific trends in catch and harvest. This action likely had the greatest influence on results for anglers targeting anything because this group is expected to be more influenced to fish a specific reservoir based on characteristics of the *reservoir* and *fish community* contained within that reservoir, whereas all other targeting groups are expected to be more influenced to fish a specific reservoir based on characteristics of a *fish population* within that reservoir. That is, we do not expect anglers targeting white bass to fish reservoirs void of white bass, which would deflate their catch rate. Thus, lower catch and harvest for anglers targeting anything relative to anglers targeting a specific taxon could be a consequence of combining catch across reservoirs. Alternatively, lower catch for anglers targeting anything could be indicative of a group comprised of low-skill anglers. Second, our survey approach precluded gathering data on multiple target taxa. It was seldom to encounter anglers targeting three or more taxon, yet it was a common occurrence to encounter anglers targeting two taxa. We instructed creel clerks to record the first taxon mentioned; thus, they recorded walleye for an answer of "walleye and white bass," whereas they recorded white bass for an answer of "white bass and walleye." As such, we do not know what proportion of the catch is bycatch (non-retained catch due to economic, legal or personal considerations plus retained catch of non-targeted taxon (Alverson et al., 1994)). Third, uncertainty remains about the taxon-targeted characteristic of anglers. Current methodology requires creel technicians to request the taxon-targeted characteristic from the angler party rather than from each individual within that party (Newcomb, 1992). It is possible that our estimates of catch and harvest would be different if the taxon targeted differs among individuals within a party. Fourth, additional uncertainty remains about the taxon-targeted characteristic of anglers. We do not know when anglers made the taxon-targeted decision that we recorded, though we presumed that decision occurred prior to initiation of the fishing trip—a necessary presumption for taxon targeted to have influenced reservoir selection. Discovery of a "hot bite" for a different taxon could, and perhaps often does, result in a change in fishing tactics for the day. Clearly, current creel surveys do not capture changes in taxon targeted, if any, during a fishing trip. Thus, responses to the question of taxon targeted today that are provided at the conclusion of the fishing trip could be a reflection of events during the fishing trip rather than intentions at the start of the trip. If a vast majority of anglers are answering this question based on events of the trip, then this question offers little insight because clerks directly quantify capture events for each trip.

The angling population is not comprised of a single, homogeneous group, but is rather a heterogeneous group made up of numerous subgroups (Arlinghaus et al., 2008; Hutt and Jackson, 2008; O'Neill, 2001). Though a single taxon of fish is targeted by segments of anglers, catch and harvest of the taxon we assessed were not confined within those respective segments of anglers. That is, all taxon assessed were captured and harvested by anglers targeting other taxon during the period of our study. We encourage managers to consider taxon-specific objectives of target and non-target catch, especially within a resilience context (Pope et al., 2014) that considers long-term changes in habitat (Pegg et al., 2015) and catches (Seekell et al., 2011). We believe doing so will lead to development of broader views and more holistic conceptualizations of interactions between fish communities and angler communities. A prerequisite for this suggested approach is an understanding of differences in demographics and behaviors of angler groups. For example, it is likely that differences in party size and time spent fishing among angler groups could influence catch and should be accounted when establishing management objectives. Fortunately, some progress has been made in describing and understanding demographics and behaviors of various angler groups (Burlingame and Guy, 1999; Hunt and Ditton, 2002; O'Neill, 2001; Ward et al., 2013b). Catch and harvest are only one piece of the puzzle—we also need to understand the functional effort (recognizing that an hour of party effort, even when standardized to party size, is not always equal among parties, across time within a day, or among days) exerted by each angler group to begin to understand the effects of angler groups on the fish community.

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Appendix A. Fixed-effect coefficients of the models for Bluegill catch (Poisson distribution) and harvest (Poisson distribution) as a function of number of anglers, fishing time (h), taxon targeted, and angler type. Reservoir was included as a random effect in these models. Coefficients for taxon targeted are relative to anglers that targeted Bluegill.

Parameter	Estimate	SE	z value	P value
	Catch			
Intercept	0.334	0.395	0.840	0.398
num.anglers	0.151	0.017	8.780	<0.001
fishing.time	0.129	0.009	14.260	<0.001
sp.targeted[anything]	−1.548	0.050	−30.690	<0.001
sp.targeted[channel catfish]	−3.602	0.135	−26.650	<0.001
sp.targeted[crappie]	−1.746	0.115	−15.160	<0.001
sp.targeted[hybrid striped bass]	−2.617	0.197	−13.300	<0.001
sp.targeted[largemouth bass]	−3.196	0.126	−25.430	<0.001
sp.targeted[walleye]	−3.451	0.064	−53.700	<0.001
sp.targeted[white bass]	−4.074	0.210	−19.390	<0.001
angler.type[boat]	−0.176	0.052	−3.410	0.001
	Harvest			
Intercept	−2.580	0.490	−5.270	<0.001
num.anglers	0.202	0.030	6.750	<0.001
fishing.time	0.172	0.014	12.220	<0.001
sp.targeted[anything]	−2.306	0.098	−23.600	<0.001
sp.targeted[channel catfish]	−4.909	0.371	−13.240	<0.001
sp.targeted[crappie]	−1.949	0.154	−12.650	<0.001
sp.targeted[hybrid striped bass]	−4.624	0.599	−7.720	<0.001
sp.targeted[walleye]	−4.238	0.104	−40.750	<0.001
sp.targeted[white bass]	−4.331	0.307	−14.100	<0.001
angler.type[boat]	−0.360	0.102	−3.540	<0.001

Appendix B. Fixed-effect coefficients of the models for Channel Catfish catch (Poisson distribution) and harvest (Poisson distribution) as a function of number of anglers, fishing time (h), taxon targeted, and angler type. Reservoir was included as a random effect in these models Coefficients for taxon targeted are relative to anglers that targeted Channel Catfish.

Parameter	Estimate	SE	z value	P value
	Catch			
Intercept	−0.689	0.160	−4.290	<0.001
num.anglers	0.090	0.012	7.800	<0.001
fishing.time	0.240	0.006	39.680	<0.001
sp.targeted[anything]	−1.645	0.040	−41.010	<0.001
sp.targeted[bluegill]	−2.218	0.306	−7.260	<0.001
sp.targeted[common carp]	−1.808	0.291	−6.210	<0.001
sp.targeted[crappie]	−3.000	0.131	−22.880	<0.001
sp.targeted[hybrid striped bass]	−2.086	0.114	−18.260	<0.001
sp.targeted[largemouth bass]	−3.054	0.162	−18.870	<0.001
sp.targeted[walleye]	−2.563	0.041	−62.200	<0.001
sp.targeted[white bass]	−2.826	0.058	−48.620	<0.001
angler.type[boat]	0.082	0.036	2.240	0.025
	Harvest			
Intercept	−1.951	0.338	−5.770	<0.001
num.anglers	0.111	0.015	7.590	<0.001
fishing.time	0.236	0.008	30.480	<0.001
sp.targeted[anything]	−1.983	0.057	−35.060	<0.001
sp.targeted[bluegill]	−2.875	0.505	−5.690	<0.001
sp.targeted[common carp]	−2.469	0.716	−3.450	<0.001
sp.targeted[crappie]	−3.333	0.185	−18.060	<0.001
sp.targeted[hybrid striped bass]	−2.568	0.263	−9.750	<0.001
sp.targeted[largemouth bass]	−3.724	0.293	−12.720	<0.001
sp.targeted[walleye]	−3.485	0.063	−55.550	<0.001
sp.targeted[white bass]	−3.218	0.078	−41.230	<0.001
angler.type[boat]	0.271	0.051	5.290	<0.001

Appendix C. Fixed-effect coefficients of the models for Common Carp catch (Poisson distribution) and harvest (zero-inflated Poisson distribution) as a function of number of anglers, fishing time (h), taxon targeted, and angler type. Reservoir was included as a random effect in these models. Coefficients for taxon targeted are relative to anglers that targeted Common Carp.

Parameter	Estimate	SE	z value	P value
	Catch			
Intercept	1.896	0.338	5.610	<0.001
num.anglers	0.067	0.041	1.620	0.100
fishing.time	0.166	0.020	8.490	<0.001
sp.targeted[anything]	−5.170	0.139	−37.120	<0.001
sp.targeted[bluegill]	−6.099	1.014	−6.020	<0.001
sp.targeted[channel catfish]	−5.137	0.172	−29.910	<0.001
sp.targeted[crappie]	−9.093	1.009	−9.010	<0.001
sp.targeted[hybrid striped bass]	−5.288	0.285	−18.540	<0.001
sp.targeted[largemouth bass]	−6.166	0.339	−18.180	<0.001
sp.targeted[walleye]	−5.825	0.145	−40.140	<0.001
sp.targeted[white bass]	−6.378	0.254	−25.120	<0.001
angler.type[boat]	−1.188	0.104	−11.440	<0.001
	Harvest			
Intercept	0.598	0.312	1.920	0.055
num.anglers	0.189	0.109	1.740	0.082
fishing.time	0.199	0.048	4.180	<0.001
sp.targeted[anything]	−3.574	0.479	−7.460	<0.001
sp.targeted[bluegill]	−11.922	66.883	−0.180	0.859
sp.targeted[channel catfish]	−4.274	0.530	−8.060	<0.001
sp.targeted[crappie]	−14.520	82.152	−0.180	0.860
sp.targeted[hybrid striped bass]	−4.201	0.827	−5.080	<0.001
sp.targeted[largemouth bass]	−14.925	152.100	−0.100	0.922
sp.targeted[walleye]	−5.979	0.579	−10.330	<0.001
sp.targeted[white bass]	−6.537	1.078	−6.070	<0.001
angler.type[boat]	−0.983	0.216	−4.550	<0.001

Appendix D. Fixed-effect coefficients of the models for crappie catch (Poisson distribution) and harvest (Negative-binomial distribution) as a function of number of anglers, fishing time (h), taxon targeted, and angler type. Reservoir was included as a random effect in these models. Coefficients for taxon targeted are relative to anglers that targeted crappie.

Parameter	Estimate	SE	z value	P value
	Catch			
Intercept	0.944	0.188	5.020	<0.001
num.anglers	0.031	0.019	1.620	0.106
fishing.time	0.152	0.007	20.640	<0.001
sp.targeted[anything]	−3.057	0.063	−48.770	<0.001
sp.targeted[bluegill]	−2.031	0.148	−13.690	<0.001
sp.targeted[channel catfish]	−5.729	0.224	−25.550	<0.001
sp.targeted[hybrid striped bass]	−3.605	0.188	−19.170	<0.001
sp.targeted[largemouth bass]	−4.076	0.145	−28.170	<0.001
sp.targeted[walleye]	−3.446	0.048	−72.360	<0.001
sp.targeted[white bass]	−4.292	0.110	−38.900	<0.001
angler.type[boat]	−0.136	0.041	−3.340	0.001
	Harvest			
Intercept	−0.454	0.446	−1.020	0.308
num.anglers	0.123	0.052	2.350	0.019
fishing.time	0.297	0.028	10.490	<0.001
sp.targeted[anything]	−3.545	0.200	−17.690	<0.001
sp.targeted[bluegill]	−2.134	0.519	−4.120	<0.001
sp.targeted[channel catfish]	−5.714	0.329	−17.380	<0.001
sp.targeted[hybrid striped bass]	−6.058	0.637	−9.510	<0.001
sp.targeted[largemouth bass]	−5.929	0.473	−12.520	<0.001
sp.targeted[walleye]	−3.996	0.191	−20.930	<0.001
sp.targeted[white bass]	−3.489	0.206	−16.950	<0.001
angler.type[boat]	−0.488	0.143	−3.410	0.001

Appendix E. Fixed-effect coefficients of the models for Hybrid Striped Bass catch (Poisson distribution) and harvest (Poisson distribution) as a function of number of anglers, fishing time (h), taxon targeted, and angler type. Reservoir was included as a random effect in these models. Coefficients for taxon targeted are relative to anglers that targeted Hybrid Striped Bass.

Parameter	Estimate	SE	z value	P value
	Catch			
Intercept	−4.834	0.620	−7.790	<0.001
num.anglers	0.281	0.071	3.970	<0.001
fishing.time	0.242	0.032	7.610	<0.001
sp.targeted[anything]	−1.891	0.199	−9.500	<0.001
sp.targeted[channel catfish]	−3.362	0.437	−7.700	<0.001
sp.targeted[crappie]	−2.803	0.605	−4.630	<0.001
sp.targeted[largemouth bass]	−3.752	0.255	−14.690	<0.001
sp.targeted[walleye]	−2.617	0.354	−7.390	<0.001
sp.targeted[white bass]	−0.369	0.247	−1.490	0.140
angler.type[boat]	−4.834	0.620	−7.790	<0.001
	Harvest			
Intercept	−4.334	0.933	−4.640	<0.001
num.anglers	0.334	0.036	9.170	<0.001
fishing.time	0.190	0.021	8.990	<0.001
sp.targeted[anything]	−1.071	0.167	−6.420	<0.001
sp.targeted[channel catfish]	−3.383	0.469	−7.220	<0.001
sp.targeted[crappie]	−2.590	0.721	−3.600	<0.001
sp.targeted[largemouth bass]	−3.040	0.721	−4.220	<0.001
sp.targeted[walleye]	−1.036	0.152	−6.840	<0.001
sp.targeted[white bass]	−0.699	0.187	−3.730	<0.001
angler.type[boat]	−0.512	0.125	−4.100	<0.001

Appendix F. Fixed-effect coefficients of the models for Largemouth Bass catch (Poisson distribution) and harvest (Poisson distribution) as a function of number of anglers, fishing time (h), taxon targeted, and angler type. Reservoir was included as a random effect in these models. Coefficients for taxon targeted are relative to anglers that targeted Largemouth Bass.

Parameter	Estimate	SE	z value	P value
	Catch			
Intercept	0.359	0.223	1.610	0.107
num.anglers	−0.054	0.025	−2.130	0.033
fishing.time	0.167	0.006	26.430	<0.001
sp.targeted[anything]	−2.395	0.056	−42.540	<0.001
sp.targeted[bluegill]	−3.019	0.280	−10.780	<0.001
sp.targeted[channel catfish]	−4.392	0.188	−23.380	<0.001
sp.targeted[crappie]	−2.415	0.124	−19.500	<0.001
sp.targeted[hybrid striped bass]	−2.629	0.226	−11.620	<0.001
sp.targeted[walleye]	−3.804	0.074	−51.090	<0.001
sp.targeted[white bass]	−2.826	0.150	−18.850	<0.001
angler.type[boat]	−0.061	0.055	−1.090	0.274
	Harvest			
Intercept	−4.834	0.620	−7.790	<0.001
num.anglers	0.281	0.071	3.970	<0.001
fishing.time	0.242	0.032	7.610	<0.001
sp.targeted[anything]	−1.891	0.199	−9.500	<0.001
sp.targeted[channel catfish]	−3.362	0.437	−7.700	<0.001
sp.targeted[crappie]	−2.803	0.605	−4.630	<0.001
sp.targeted[walleye]	−3.752	0.255	−14.690	<0.001
sp.targeted[white bass]	−2.617	0.354	−7.390	<0.001
angler.type[boat]	−0.369	0.247	−1.490	0.140

Appendix G. Fixed-effect coefficients of the models for Walleye catch (Poisson distribution) and harvest (Poisson distribution) as a function of number of anglers, fishing time (h), taxon targeted, and angler type. Reservoir was included as a random effect in these models. Coefficients for taxon targeted are relative to anglers that targeted Walleye.

Parameter	Estimate	SE	z value	P value
	Catch			
Intercept	−1.521	0.240	−6.340	<0.001
num.anglers	0.118	0.008	13.890	<0.001
fishing.time	0.187	0.004	51.150	<0.001
sp.targeted[anything]	−1.397	0.039	−35.820	<0.001
sp.targeted[bluegill]	−2.337	0.243	−9.610	<0.001
sp.targeted[channel catfish]	−3.349	0.133	−25.180	<0.001
sp.targeted[common carp]	−3.066	0.715	−4.290	<0.001
sp.targeted[crappie]	−1.919	0.092	−20.750	<0.001
sp.targeted[hybrid striped bass]	−1.208	0.133	−9.060	<0.001
sp.targeted[largemouth bass]	−2.573	0.163	−15.790	<0.001
sp.targeted[white bass]	−2.069	0.068	−30.290	<0.001
angler.type[boat]	0.660	0.045	14.670	<0.001
	Harvest			
Intercept	−2.761	0.331	−8.340	<0.001
num.anglers	0.235	0.012	20.240	<0.001
fishing.time	0.152	0.006	27.380	<0.001
sp.targeted[anything]	−1.640	0.063	−25.900	<0.001
sp.targeted[bluegill]	−2.596	0.448	−5.800	<0.001
sp.targeted[channel catfish]	−3.515	0.231	−15.220	<0.001
sp.targeted[crappie]	−2.040	0.158	−12.880	<0.001
sp.targeted[hybrid striped bass]	−1.301	0.251	−5.170	<0.001
sp.targeted[largemouth bass]	−3.625	0.448	−8.090	<0.001
sp.targeted[white bass]	−2.226	0.112	−19.880	<0.001
angler.type[boat]	0.573	0.070	8.250	<0.001

Appendix H. Fixed-effect coefficients of the models for White Bass catch (Poisson distribution) and harvest (Poisson distribution) as a function of number of anglers, fishing time (h), taxon targeted, and angler type. Reservoir was included as a random effect in these models. Coefficients for taxon targeted are relative to anglers that targeted White Bass.

Parameter	Estimate	SE	z value	P value
	Catch			
Intercept	−1.463	0.521	−2.810	0.005
num.anglers	0.114	0.009	13.000	<0.001
fishing.time	0.247	0.005	51.090	<0.001
sp.targeted[anything]	−1.809	0.036	−50.090	<0.001
sp.targeted[bluegill]	−1.988	0.450	−4.420	<0.001
sp.targeted[channel catfish]	−3.479	0.087	−40.180	<0.001
sp.targeted[crappie]	−2.177	0.078	−28.010	<0.001
sp.targeted[hybrid striped bass]	−1.737	0.086	−20.160	<0.001
sp.targeted[largemouth bass]	−2.779	0.109	−25.600	<0.001
sp.targeted[walleye]	−2.035	0.027	−74.950	<0.001
angler.type[boat]	0.737	0.041	17.800	<0.001
	Harvest			
Intercept	−2.634	0.826	−3.190	0.001
num.anglers	0.153	0.012	12.860	<0.001
fishing.time	0.286	0.008	38.110	<0.001
sp.targeted[anything]	−2.223	0.051	−43.540	<0.001
sp.targeted[bluegill]	−1.967	0.583	−3.380	0.001
sp.targeted[channel catfish]	−4.324	0.133	−32.400	<0.001
sp.targeted[crappie]	−2.492	0.130	−19.200	<0.001
sp.targeted[hybrid striped bass]	−2.032	0.163	−12.430	<0.001
sp.targeted[largemouth bass]	−4.208	0.275	−15.320	<0.001
sp.targeted[walleye]	−2.706	0.042	−63.850	<0.001
angler.type[boat]	0.487	0.051	9.480	<0.001

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