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Self-imposed length limits in recreational fisheries

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ABSTRACT

A primary motivating factor on the decision to harvest a fish among consumptive-orientated anglers is the size of the fish. There is likely a cost-benefit trade-off for harvest of individual fish that is size and species dependent, which should produce a logistic-type response of fish fate (release or harvest) as a function of fish size and species. We define the self-imposed length limit as the length at which a captured fish had a 50% probability of being harvested, which was selected because it marks the length of the fish where the probability of harvest becomes greater than the probability of release. We assessed the influences of fish size, catch per unit effort, size distribution of caught fish, and creel limit on the self-imposed length limits for bluegill *Lepomis macrochirus*, channel catfish *Ictalurus punctatus*, black crappie *Pomoxis nigromaculatus* and white crappie *Pomoxis annularis* combined, white bass *Morone chrysops*, and yellow perch *Perca flavescens* at six lakes in Nebraska, USA. As we predicted, the probability of harvest increased with increasing size for all species harvested, which supported the concept of a size-dependent trade-off in costs and benefits of harvesting individual fish. It was also clear that probability of harvest was not simply defined by fish length, but rather was likely influenced to various degrees by interactions between species, catch rate, size distribution, creel-limit regulation and fish size. A greater understanding of harvest decisions within the context of perceived likelihood that a creel limit will be realized by a given angler party, which is a function of fish availability, harvest regulation and angler skill and orientation, is needed to predict the influence that anglers have on fish communities and to allow managers to sustainable manage exploited fish populations in recreational fisheries.

1. Introduction

Recreational harvest is an integral component of most inland fisheries in North America, Europe, and Australia that affects population viability, community interactions, and fishery quality (Isermann and Paukert, 2010; Post, 2013). As such, regulating the harvest of fish by anglers is a common practice within fishery management. A creel or bag limit – the number of fish that can be harvested per fishing day – is the most common type of regulation for recreational angling (Isermann and Paukert, 2010), and most regulating agencies prohibit “culling” or “high grading” (i.e., the act of releasing a fish that has been retained on a stringer, in a bucket, or in a livewell so that a more desirable, often larger, fish may be retained) of fish (Isermann and Paukert, 2010). Thus, an immediate decision must be made at capture on whether to harvest or release a fish that is protected with only a creel limit, and this decision process is repeated with the capture of each subsequent fish. Anglers elect to harvest select species and sizes of captured fish for personal, practical, economic, and regulatory reasons, and the decision of an angler to harvest a captured fish is likely influenced by previous and current angling catch rates, previous and current angling effort, current motivating factors for participating in recreational angling, and current social normative pressures (Hunt et al., 2002; Beardmore et al., 2011). Therefore, the decision to harvest or release a captured fish is likely to depend on the attitudes and characteristics of the angler and is influenced by regulations, species, and size of fish.

There are many factors affecting the decision to harvest fish (Hunt et al., 2002), but the size of a fish is an important motivating factor (Fisher, 1997). The satisfaction gained from harvesting a fish is likely to increase with fish size for most inland freshwater fishes because one potential benefit of harvesting the fish, amount of meat gained, is related to fish size (Willis and Van Zee, 1997; Rutten et al., 2004), whereas one potential cost of harvesting the fish, effort and

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time required to process the harvested fish, is likely only marginally related to fish size. Therefore, the size of fish where the benefit of harvest begins to exceed the cost of harvest likely creates a self-imposed size (length) limit below which an angler releases all or nearly all captured fish even when no formal size limit has been enacted (Stewart and Ferrell, 2003). Although the size of the fish may set a baseline around which decisions are based, other factors may interact with size in the decision to harvest. For example, Näslund et al. (2010) showed that the probability of retaining an individual fish increased with fish size and the enactment of minimum size limits. Further, over time the size at 50% probability of harvest increased with time post regulation change for grayling *Thymallus thymallus* L. in the River Ammerån, Sweden.

Anglers often use regulatory creel limits as a basis to measure their skill or assess the condition of a fishery (Snow, 1982; Noble and Jones, 1993) and the restrictiveness of a regulation can affect angler satisfaction (Cook et al., 2001) and behavior (Beard et al., 2003). Though anglers are more satisfied with more attainable creel limits (Cook et al., 2001), the effect of a creel limit on the size of fish harvested and its interplay with the satisfaction of harvest is unknown. Given an assumption of constant catch rates, we hypothesize that a consumptive-orientated angler would be less selective in the size of the fish harvested from a waterbody with a liberal creel limit, particularly a creel limit that is rarely attained by the angler, because quantity of the fish harvested (i.e., maximization of biomass) likely outweighs the quality of any individual fish harvested. Likewise, we hypothesize that an angler would be more selective in the size of fish harvested from a waterbody with a restrictive creel limit, particularly a creel limit that is frequently attained by the angler, because quality of any individual fish harvested likely outweighs the quantity of the fish harvested. If this hypothesis is correct, then the self-imposed size limits across anglers would encompass a greater size range for waterbodies regulated with a liberal creel limit compared to waterbodies regulated with a restrictive creel limit.

In an effort to simplify regulations, the Nebraska Game and Parks Commission reduced the daily creel limit for channel catfish *Ictalurus punctatus* from 10 to 5 and a reduced the daily creel limit for panfish (includes lepomids, pomoxids, and yellow perch *Perca flavescens*) from 30 to 15, effective 1 January 2011. There was no change in the daily creel limit for temperate bass, which was set at 15; thus, white bass *Morone chrysops* was included as a control for this assessment. These changes in creel limits toward more restrictive creel limits offered us the opportunity to assess the effect of creel limits on the size of the fish harvested. These fishes were not regulated with length limits in the reservoirs assessed. The objective of this study was to determine what influence, if any, these more restrictive creel limits had on the anglers' effective (i.e., self-imposed) length limits for these fishes in reservoirs throughout Nebraska.

2. Materials and methods

Anglers were interviewed during 2010 and 2011 to document angler participation patterns, fishing pressure, catch and harvest at reservoirs across Nebraska. Interviews took place at Enders Reservoir, Harlan County Lake, Medicine Creek Reservoir, Merritt Reservoir, Red Willow Reservoir, Swanson Reservoir, and Sherman Reservoir between 1 April and 31 October. One angler, the representative of the party, completed the survey per interview; thus, all data were collected at the party (i.e., a group of individuals travelling together for the purpose of fishing) level. Though anglers with complete and incomplete trips were interviewed, only completed trips were used in this study. A stratified multi-stage probability sampling regime (Malvestuto, 1996) was used to determine days of interviews. Totals of 10 or 20 days were surveyed per month at each reservoir as determined by logistical constraints. Surveys were stratified by day-type with 6 weekdays and 4 weekend and holiday days per month or 14 weekdays and 6 weekend and holiday days per month. Each creel day was further stratified into two survey periods (sunrise to 1330 [morning] and 1330 to sunset [afternoon]). During the interview process, harvested fish were measured by creel clerks and lengths of released fish were recorded as specified by the angler.

Data were combined across reservoirs for analyses. To maintain species-specific estimates of size at harvest, we excluded any party that harvested multiple species subjected to one regulation, except for black crappie *Pomoxis nigromaculatus* and white crappie *Pomoxis annularis*, which were considered a single group. For example, an angler party that harvested bluegill *Lepomis macrochirus* and yellow perch, species both regulated under the panfish creel limit, was excluded from all analyses. Thus, interpretations provided herein are based on the premise that creel limits were species specific rather than aggregate. Mixed-effects logistic regression (Venables and Dichmont, 2004) was used for each species to predict whether a captured fish was harvested given its length, year in which it was captured (2010 = pre-creel restriction; 2011 = post-creel restriction), catch per unit effort (CPUE), and the length × year interaction using the *lme4* package (Bates et al., 2013) in R (R Development Core Team, 2012). In this analysis, we treated reservoir as a random effect, and length, year, CPUE, and the length × year interaction as fixed effects. The CPUE was calculated as the number of fish caught per angler per hour for each party. The predicted probabilities of harvest and 95% confidence intervals were calculated across species-specific size ranges (i.e., sizes of fish caught by anglers) using the coefficient values and standard errors from fixed effects. A mean CPUE across the two years for each species was used to standardize the predictions across the two years. We define the self-imposed length limit as the length at which a captured fish had a 50% probability of being harvested, which was selected because it marks the length of the fish where the probability of harvest becomes greater than the probability of release. Proportional size distributions (PSDs; Guy et al., 2007) for fishes caught (harvested plus released) by anglers were calculated for each species during each year according to lengths specified by Anderson and Nuemann (1996) and 95% confidence intervals were calculated following Gustafson (1988). Chi-square analysis was used to assess differences in proportions of parties harvesting their creel limit between years as well as differences in PSDs between years. We set our level of significance at $\alpha = 0.05$.

3. Results

Data for this study came from 1584 interviews that comprised 3085 anglers during 2010 and 2011. Length and fate (harvested or released) information was collected on 1007 bluegill (total-length range = 8.0–34.0 cm), 3462 channel catfish (8.0–99.0 cm), 4025 crappie (8.0–41.0 cm), 10387 white bass (4.9–48.0 cm), and 1390 yellow perch (8.0–35.5 cm) (Table 1). The mean ± SE CPUE for bluegill (2010: 0.12 ± 0.02; 2011: 0.05 ± 0.01) and channel catfish (2010: 0.14 ± 0.01; 2011: 0.12 ± 0.01) decreased from 2010 to 2011, whereas mean CPUE for crappie (2010: 0.23 ± 0.08; 2011: 0.55 ± 0.06) and white bass (2010: 0.31 ± 0.06; 2011: 0.54 ± 0.04) increased from 2010 to 2011, and mean CPUE for yellow perch (2010: 0.10 ± 0.02; 2011: 0.09 ± 0.01) remained consistent from 2010 to 2011.

There was no significant change in the percentage of parties that caught their limit of bluegill ($\chi^2 = 0.12$, df = 1, $P = 0.72$), white bass ($\chi^2 = 0.48$, df = 1, $P = 0.49$), channel catfish ($\chi^2 = 2.25$, df = 1, $P = 0.13$), or yellow perch ($\chi^2 = 2.07$, df = 1, $P = 0.15$), whereas the