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Assessment of a channel catfish population in a large open river system

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Abstract

Estimates of dynamic rate functions for riverine channel catfish, *Ictalurus punctatus* (Rafinesque), populations are limited. The open nature and inherent difficulty in sampling riverine environments and the propensity for dispersal of channel catfish impede estimation of population variables. However, contemporary population models (i.e. robust design models) can incorporate the open nature of these systems. The purpose of this study was to determine channel catfish population abundance, survival and size structure and to characterize growth in the lower Platte River, Nebraska, USA. Annual survival estimates of adult channel catfish were 13%–49%, and channel catfish abundance estimates ranged from 8,281 to 24,261 fish within a 10-km sampling reach. Channel catfish were predominantly (90%) <age 5 and <400 mm total length, and adult growth was similar to other populations across the species' range. The channel catfish population characteristics in the lower Platte River are likely a result of a combination of factors including recreational harvest and potential shifts in habitat during different life stages. A multifaceted sampling and analytical approach provided additional information such as movement and abundance estimates and may also help to decipher abiotic and biotic factors that interact when managing fish populations in riverine environments.

Keywords: mark, mark–recapture, open system, population estimation, robust design, survival

1 Introduction

Managing fish populations in large rivers is difficult due to the unique characteristics of these systems and the fish species that inhabit them (Paukert & Galat, 2010). Large rivers contain vast expanses of non-fragmented sections with connections to tributaries and floodplain lakes (i.e. open systems). In addition, many large-river fish move long distances to carry out varied life-history strategies in suitable habitats (Pracheil, Pegg, Powell & Mestl, 2012). The combination of the size of large-river systems and the ability of large-river fishes to move long distances has limited fisheries scientists' ability to measure population variables and adopt adequate management strategies. For instance, truncated size structure of riverine fish populations, potentially resulting from moderate to high levels of harvest, may be masked by the movement of individuals among connected river reaches. Coupling these issues with the prevalence of anthropogenic alteration that has occurred in the world's river systems further exemplifies the complexity in riverine environments. Subsequently, the extent to which fish populations experience changes in abundance and size and age structure, and influences on population dynamics within these complex systems is relatively unknown.

Riverine channel catfish, *Ictalurus punctatus* (Rafinesque), populations offer valuable resources for recreational anglers, providing both harvest- and trophy-oriented fisheries that have likely contributed to the increase in angler interest in catfish as a sport fish over the last several years (Arterburn, Kirby & Berry, 2002; Kwak, Porath, Michaletz & Travnichek, 2011). As the popularity of recreational catfishing continues, increased fishing effort may result in reduced abundance, decreased size structure or reduced catch rates (Lewin, Arlinghaus & Mehner, 2006). Pitlo (1997) found commercial harvest resulted in a highly skewed proportion of small catfish in the Upper Mississippi River. By contrast, Gerhardt and Hubert (1991) described a lightly exploited channel catfish population to contain an abundance of older (up to 21 years) and larger individuals compared to other exploited populations. Furthermore, a general understanding of catfish populations, particularly in open riverine systems, is limited (Bodine et al., 2013; Michaletz & Dillard, 1999). Previous work on riverine channel catfish populations has relied largely on tracking relative abundance (i.e. catch per unit effort) and analyzing growth and mortality based on ages assigned from analysis of ageing structures that may or may not have been completely validated (Spurgeon, Hamel, Pope & Pegg, 2015). Although this work provides some insight to how populations may be responding to abiotic or biotic conditions, the inference base to which these data can be applied often is unknown. Mark–recapture studies hold promise for assessing riverine catfish populations as statistical approaches are now available to accommodate the open nature of these systems (viz. robust design, Williams, Nichols & Conroy, 2002). However, these techniques have not been applied to channel catfish populations in river systems. Studies estimating population demographics including abundance and survival within a robust statistical framework (i.e. robust design) are needed, particularly in open river systems, to inform future management decisions.

Channel catfish angling in Nebraska, USA, historically has been popular with more than 50% of Nebraska anglers in 1981 and 1982 (Zuerlein, 1984) and 57% in 2002 (Hurley & Duppong-Hurley, 2005) fishing specifically for catfish. Furthermore, 35% of anglers spent their time targeting catfish populations over all others species within the state's rivers and streams (Zuerlein, 1984). Peters and Parham (2008) reported channel catfish as being the most sought after species in the Platte River in Nebraska, and previous reports have suggested anglers fishing the lower Platte River are harvest oriented (Hamel & Pegg, 2009; Holland & Peters, 1994). Therefore, a complete assessment of the Platte River channel catfish fishery is needed to inform managers about the current characteristics of the fishery. The purpose of this study was to determine channel catfish population abundance, survival, size structure and growth rates in the lower Platte River. This study provides a baseline to assess the status of a riverine channel catfish population that is currently undergoing potentially high exploitation and human-induced abiotic affects. Additionally, this study highlights the use of advanced mark–recapture models intended to increase understanding of fish population dynamics in open systems.

2 Methods

2.1 Study area

The lower Platte River is recognized as the 165 river kilometers (rkm) from the confluence of the Loup River near Columbus, Nebraska to the confluence at the Missouri River near Plattsmouth, Nebraska (Figure 1). The Platte River is a wide (approximately 500–600 m), shallow river with depths that rarely exceed 1.5 m. It is a braided sand-bottom river with meandering channels that are dynamic throughout the year. Few physical alterations (e.g. dams or channel training structures) have been constructed, but the flow regime is heavily modified (see Hamel, Spurgeon, Pegg, Hammen & Rugg, 2016) to support anthropogenic activities such as agricultural and domestic water withdrawals and hydroelectric power generation.

A previous study developed to assess the channel catfish fishery in the lower Platte River established fixed sampling sites that were chosen due to accessibility, angling fishing effort and hydrological conditions (Barada & Pegg, 2011). Despite the connectedness throughout the lower Platte River, Barada and Pegg (2011) suggested that population abundance and dynamics varied among sampling sites; particularly between river segments above and below the Elkhorn River confluence with the Platte River (Figure 1). The Elkhorn River strongly influences hydrological differences between these sites (Spurgeon, Hamel & Pegg, 2016). As such, two 10-km-long sampling sites were selected in the lower Platte River near Louisville (rkm 26; below the Elkhorn River confluence) and Fremont (rkm 90; above the Elkhorn River confluence). Angler distribution and exploitation data are limited for much of the Platte River system, but fishing effort is thought to be concentrated near these two urban areas that provide two of only three public access locations to the lower Platte River. The Fremont location is subject to lower water quantity and extreme diel fluctuations in the hydrograph as a result of hydropeaking from a hydroelectric dam on the Loup River power canal that diverts water from the Loup River prior to flowing into the Platte River (Hamel et al., 2016; Spurgeon et al., 2016). The Louisville site has a more stable hydrograph and greater discharge due to flow from the Elkhorn River.

2.2 Channel catfish collection

A robust-design sampling protocol was used where each site was sampled most days during alternating weeks from April to November in 2010 and 2011. Robust sampling designs include primary sampling periods (sampling week) with repeated secondary sampling periods (days sampled during the week) that occur during the short time interval within each primary period. Channel catfish were collected using equal numbers (N = 10) of 0.6-m diameter, seven hoop, 25-mm square mesh (seven-hoop) hoopnets and 0.5-m diameter, four hoop, 25-mm square mesh (four-hoop) hoopnets baited with cheese trimmings. Hoopnets were anchored at the cod end and an anchor lead was tied to the shoreline in areas of sufficient depth and velocity (i.e. to have the net submerged and functioning properly). Varying hoopnet dimensions were used to ensure adequate coverage of channel catfish size and abundance. Electric fishing was used to complement hoopnet data as a means to sample larger fish not susceptible to the hoopnet configurations used in this study (size of net was limited by depth). Electric fishing was performed using a cataraft (River King Catarafts, Port Ludlow, WA, USA) equipped with a MBS-2D Wisconsin control box (ETS Electrofishing LLC, Madison, WI, USA) powered by a 3,500 W/240 V generator. Sampling alternated between high-frequency (4–8 A, 180–240 V, 60 pulses/s, 50% pulse width) and low-frequency (3–5 A, 180–240 V, 15 pulses/s, 20% pulse width) pulsed DC settings. April collections were conducted with only 4-hoop hoopnets to maintain standardized protocols for an ongoing long-term assessment. Channel catfish were weighed (g) and measured for total length (TL, mm). Pectoral spines were collected from five individuals from each 10-mm TL size group to assess age structure and growth. Additionally, channel catfish ≥200 mm TL were tagged with FD-94 T-bar anchor tags (Floy Mfg.; Seattle, WA, USA) inserted between the dorsal pterygiophores. All tags had a unique identifier number and a phone number for anglers to report tagged fish.

2.3 Ageing

Pectoral spines were prepared using procedures similar to Koch and Quist (2007) and sectioned using a Buehler low-speed saw (Buehler

Ltd, Lake Bluff, IL, USA). Three sections (0.50–0.75 mm) were cut immediately distal to the basioccipital process and mounted on a microscope slide with slide cement (Cytoseal; Buehler Ltd). A single image of the clearest spine section was recorded using a microscope-mounted camera, and two readers independently estimated age (Barada, Blank & Pegg, 2011). Disagreements in age estimates were resolved with a concert reading.

2.4 Data analysis

Estimates of population abundance and survival as well as capture and movement (i.e. into and out of study area) rates were derived using mark–recapture data collected under the robust-design framework (Kendall, Nichols & Hines, 1997). Assumptions of the robust design include population closure across all secondary sampling periods within a primary time period (i.e. days within a week), temporary emigration is either completely random, Markovian or based on a temporary response to first capture, and survival rates are the same for all animals in the population regardless of availability for capture. Annual survival (S) and emigration parameters (γ' and γ'') were held time-constant because it was hypothesized a priori that sample size might limit the number of estimable parameters using the parameter-rich robust design models (Kendall et al., 1997). Temporal variation was incorporated by allowing capture (p), recapture (c) and population size (N) to vary by primary period. Models included scenarios of equal or unequal capture and recapture probabilities (i.e. $p. = c.$ or $p. \neq c.$), as well as varying estimates of N by combined years ($N.$) or separate years (N_{yearly}). Population estimates were determined as the number of channel catfish ≥200 mm in the effective sampling area (i.e. sampling sites).

The major advantage of the robust design is the capability to estimate temporary emigration rates by two parameters: γ' and γ''. The γ' parameter is defined as the probability an individual that is outside the study area remains outside in the next primary time period, given the individual survives to the next time period; γ'' is the probability an animal within the study area emigrates from the study area in the next primary time period, given that it survives (Kendall et al., 1997). Three different scenarios of γ' and γ'' ($\gamma' = \gamma''$, $\gamma' \neq \gamma''$ and $\gamma' = \gamma'' = 0$) were used. The first scenario, $\gamma' = \gamma''$, refers to random emigration (Kendall et al., 1997), in which the probability that an individual was away from the study area was the same, regardless of its position the previous time period. The second, $\gamma' \neq \gamma''$, or Markovian emigration (Kendall et al., 1997), refers to the probability of an individual being away from the study area could depend on its position (e.g. in the study area or away) during the previous time period. Lastly, $\gamma' = \gamma'' = 0$, or no emigration, specifically describes a scenario in which no emigration occurred. A suite of robust-design models was constructed in Program Mark and the models were ranked using Akaike's information criterion corrected for small sample size (AICc; White & Burnham, 1999; Burnham & Anderson, 2002).

Incremental proportional size distributions (PSD; Neumann, Guy & Willis, 2012) were calculated from all channel catfish collected based on length categories described by Gabelhouse (1984); PSD values were calculated for both Fremont and Louisville and compared with a chi-square test (Neumann & Allen, 2007). Channel catfish length distributions were compared between sites and gear types using a Kolmogorov–Smirnov test. Relative abundance (catch per unit effort; CPUE) of taggable-size fish (≥200 mm) was calculated for hoopnets at each site. Catch data were log10 (CPUE+1) transformed to meet assumptions of normality. Body condition of all channel catfish was assessed for both sampling sites using relative weight (W_r; Murphy, Brown & Springer, 1990), and individual length-at- age was estimated using the Dahl-Lea method for back calculations (DeVries & Frie, 1996). Comparisons of CPUE, W_r and growth (i.e. mean length-at- age) were analyzed with analysis of variance (ANOVA) with Tukey's HSD multiple comparisons when significant differences were identified. Analyses were conducted using program R (R Core Team, 2016; http://www.R-project.org), and significance was determined at $\alpha = 0.05$.

3 Results

3.1 Population survival and density estimates

A total of 5,459 channel catfish were captured and tagged from 2,407, 4-hoop and 7-hoop hoopnet deployments and 61.3 hr of electric fishing. The best-fit models were the same for both sites and included equal capture and recapture rates that varied by primary period, population estimates that varied by year and unequal emigration parameters (Tables 1 and 2). Daily survival estimates ranged from 0.9944 (13% annual survival) at Louisville to 0.9981 (49% annual survival) at Fremont. Temporary emigration estimates of γ'' were lower at Louisville (0.78, *SE* = .03, 95%; CI = 0.70–0.84) compared to Fremont (0.90, *SE* = .01, 95%; CI = 0.87–0.92); however, estimates of γ' were equal between sites (0.99, *SE* = .00071 at Louisville; 0.99, *SE* = .00085 at Fremont). Capture and recapture probabilities had a range of 0.0011–0.0060) at Louisville and 0.0016–0.0086 at Fremont. Population estimates at Louisville were 8,281 (*SE* = 1,486) in 2010 and 11,620 (*SE* = 2,016) in 2011, and estimates for Fremont were 24,261 (*SE* = 4,707) in 2010 and 14,359 (*SE* = 2,283) in 2011.

3.2 Population characteristics

The length frequency distribution of captured channel catfish was similar between four-hoop and seven-hoop hoopnets ($D = 0.033$; $p = .139$), and catch was therefore pooled for further assessments. The median length of channel catfish collected with electric fishing (median length = 326 mm) was larger than for hoopnets; however, there were no significant differences in the length frequency distributions between both hoopnet configurations and electric fishing ($D = 5.6$; $p = .074$). Collectively, median lengths of captured channel catfish were 269 mm and 256 mm at Louisville and Fremont (Figure 2), but length frequency distributions differed between sites, with a larger number of smaller channel catfish collected at Fremont ($D = 0.098$; $p < .001$). Incremental PSD similarly resulted in higher PSD S-Q at Fremont compared to Louisville ($X^2 = 25.65$; $p < .001$; Table 3), whereas PSD Q-P was higher at Louisville ($X^2 = 20.12$; $p < .001$). Relative abundance of channel catfish was higher at Fremont in both years ($F_{3,2403} = 28.28$, $p < .001$; Figure 3). Mean W_r was 90 (*SE* = 3.5) and 89 (*SE* = 4.6) for Louisville and Fremont across both years and gear types (i.e. electric fishing and hoopnets; Figure 4). Mean growth increment was greater for age 2 to age 4 channel catfish at Louisville compared to Fremont (Figure 5), but not different for other age groups between sites. Channel catfish length-at-age was similar between Louisville and Fremont

(Figure 6), and 90% of all fish were less than age 5 (mean age = 3). There were 154 angler returns from the 5,562 channel catfish tagged at both Louisville and Fremont. Of these, 83 channel catfish were reported to be harvested resulting in an exploitation rate of 54%.

4 Discussion

Channel catfish annual survival estimates from the robust statistical framework ranged from 13% to 49%. Survival was within the lower range of previous survival estimates for channel catfish populations. In a survey conducted of >50 channel catfish populations, annual survival ranged from 12% to 87% (Hubert, 1999); however, those estimates were calculated via catch–curve mortality estimates that may not be sensitive to detect the effects of movement (i.e. emigration and immigration) or specific mortality events at finer time scales. Despite the potential statistical limitations, annual survival of channel catfish in lightly exploited systems appeared to be higher compared to the lower Platte River. For instance, annual survival in the Red River, Manitoba was 95% (multi-state model survival parameter; Siddons, 2015), 85% in the Ottawa River system (catch curve; Haxton & Punt, 2004) and 77% in the Powder River system (catch curve; Gerhardt & Hubert, 1991). Conversely, annual survival estimates from a commercially exploited population of channel catfish in the Wabash River, Indiana ranged from 50% to 72% (catch curve; Colombo, Phelps, Garvey, Heidinger & Stefanavage, 2008). A combination of factors is likely responsible for the lower survival estimates in this study compared to previously published estimates. In addition to angler exploitation, natural mortality and movement out of the Platte River likely contributes to low survival estimates. The hydrological character of the Platte River (i.e. dynamic flow regime and hydropeaking) has been proposed as a potential driver of high natural mortality of channel catfish (Barada & Pegg, 2011), and the 78%–90% temporary emigration rate estimated for this study indicates that movement of channel catfish from within study sites and potentially out of the Platte River system is substantial. Currently, it remains unclear which driver (biotic or abiotic) is predominately responsible for the truncated size structure and prevalence of young fish in the system, but both likely contribute and separation of the two will aid in directing future management strategies.

Channel catfish collected in the lower Platte River near Fremont and Louisville, Nebraska, were predominately (90%) <age-5 and <400-mm long. Channel catfish have been reported to attain much older ages and larger sizes in other riverine environments. For example, channel catfish exceed 20 years of age and attain sizes greater than 800 mm TL in the lightly exploited Powder (Wyoming, USA) and Red (Manitoba, Canada) rivers (Gerhardt & Hubert, 1991; Michaletz & Dillard, 1999; Siddons, 2015). The current study suggests a greater prevalence of younger and smaller fish in the lower Platte River despite growth being slightly above the 50th percentile of channel catfish growth from across the species' range (Figure 6).

Proportionately few large (and presumably old) fish were collected in this study. Repeated sampling with standardized gears was relied on to provide information on channel catfish population characteristics. Hoopnets have been shown to be effective for assessing size structure for channel catfish populations in rivers (Buckmeier & Schlechte, 2009); however, different configurations and gear types can influence population variables (Colombo, Phelps, Garvey, Heidinger & Stefanavage, 2008). Electric fishing was employed to potentially sample larger channel catfish not susceptible to hoop nets configured in this study; however, length frequency distributions were similar between gears. Therefore, the reported size structure in this study was considered to be representative of the population.

Previous studies have examined exploitation patterns for various channel catfish fisheries. Santucci, Wahl and Storck (1994) reported exploitation as high as 83% for channel catfish >250 mm in small Illinois impoundments. Pitlo (1997) and Slipke, Martin, Pitlo and Maceina (2002) determined that commercial fishers were overexploiting channel catfish in the Upper Mississippi River at exploitation levels between 45% and 82%. Conversely, the channel catfish fishery in the Powder River, Wyoming was considered lightly exploited at approximately 2%. Exploitation of channel catfish in the Platte River was moderately high (54%), and previous studies from the lower Platte River (Barada & Pegg, 2011; Peters & Holland, 1994) coupled with anecdotal evidence from annual angling and set line tournaments near Fremont, NE (J. J. Spurgeon, University of Nebraska; personal communication) suggest that harvest of channel catfish may be intensive at times and locations. Persistent selective harvest of larger individuals has been shown to truncate size and age distributions (Lewin et al., 2006), and non-commercial harvest (i.e. recreational and subsistence) of freshwater fish populations has the potential to negatively influence population demographics (Cooke & Cowx, 2004; Post, 2013). Anglers' propensity to harvest channel catfish in the Platte River (Hamel & Pegg, 2009; Holland & Peters, 1994) may have contributed to a population composed of young and small individuals as observed in this study. Future work to couple exploitation patterns, both temporally and spatially, to changes in size structure would help to decipher mechanisms responsible for the observed size structure in the Platte River.

Channel catfish in this study exhibited similar growth rates compared to channel catfish populations across the species range (Hubert, 1999). Additionally, condition of channel catfish appears satisfactory. Therefore, the influence of density dependent processes seems unlikely in explaining the observed size and age structure (i.e. young and small) of channel catfish in the Platte River. Instead, in concert with the potential for harvest-mediated influences on age and size structure, the prevalence of young and small channel catfish within the lower Platte River may result from shifts in habitat use by channel catfish within the study reaches. Vokoun and Rabeni (2002) suggested large braided rivers such as the Platte River may provide optimum rearing conditions for channel catfish. The consistent catch of young and small fish in the Platte River may be due to the river providing optimal conditions for these individuals; and movement away from study sites, as suggested by the robust design analysis, may indicate shifts in habitat use as these individuals grow.

Understanding channel catfish population dynamics within open systems is an important challenge as managers attempt to promote recreational catfishing opportunities. This study suggested the channel catfish population in the lower Platte River consisted of younger and smaller individuals compared to lightly exploited catfish populations in other systems. Using the robust design framework in combination with standard population demographic indices provided additional information such as movement and abundance estimates to gain more of a complete perspective of how the fishery is functioning. Population characteristics of riverine channel catfish are likely influenced by several biotic and abiotic factors that shape size structure and mediate growth. Continued use of this population estimation methodology can provide insight into both long-term population demographic trends and addressing movement patterns and transition probabilities.

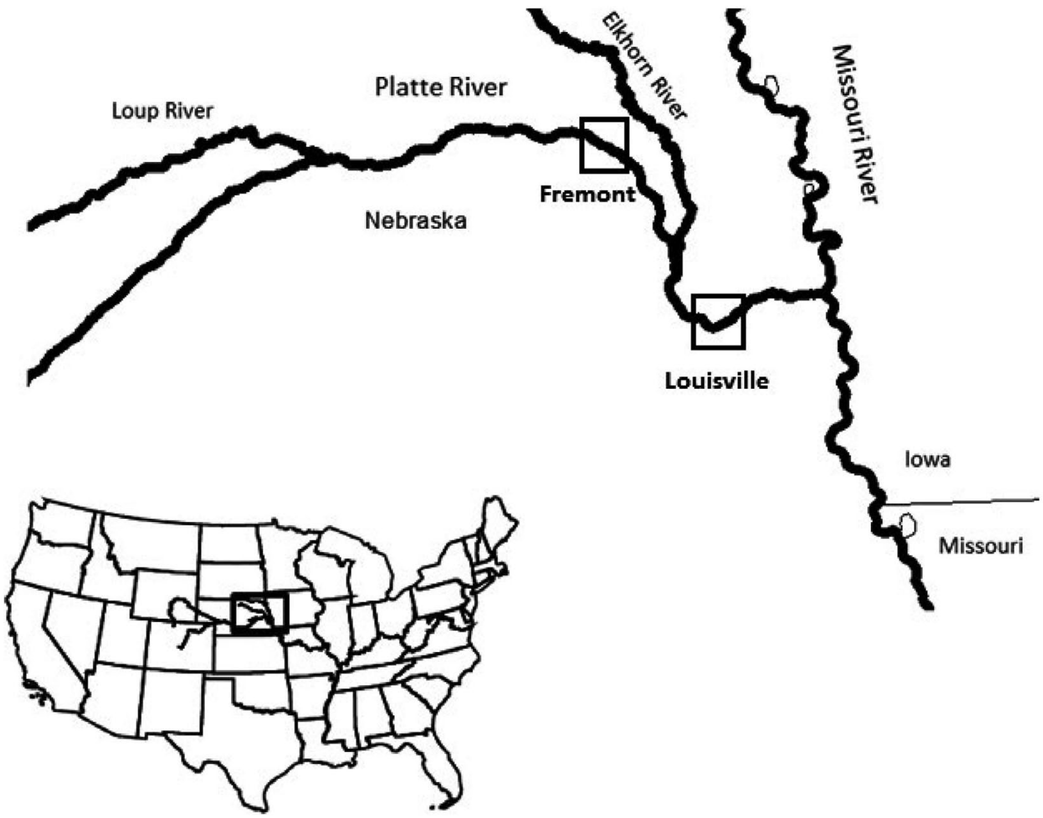

Figure 1. Study area including sampling locations in the Platte River at Louisville and Fremont, Nebraska.

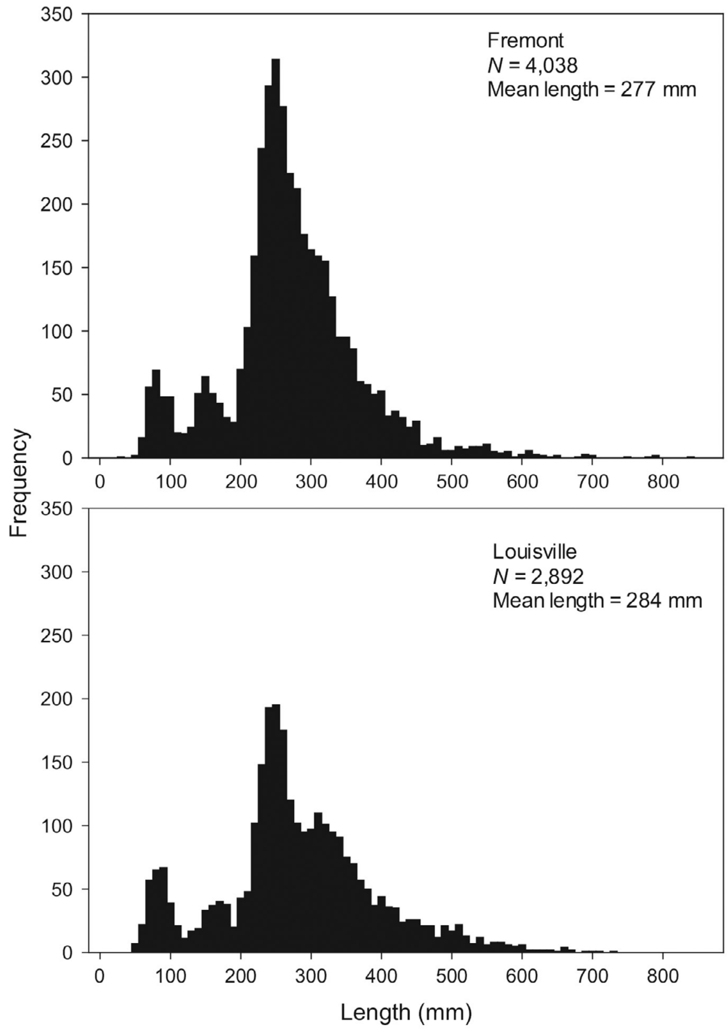

Figure 2. Length distributions of channel catfish collected with hoopnets and electric fishing in the Platte River at Fremont (top) and Louisville (bottom), Nebraska during 2010 and 2011.

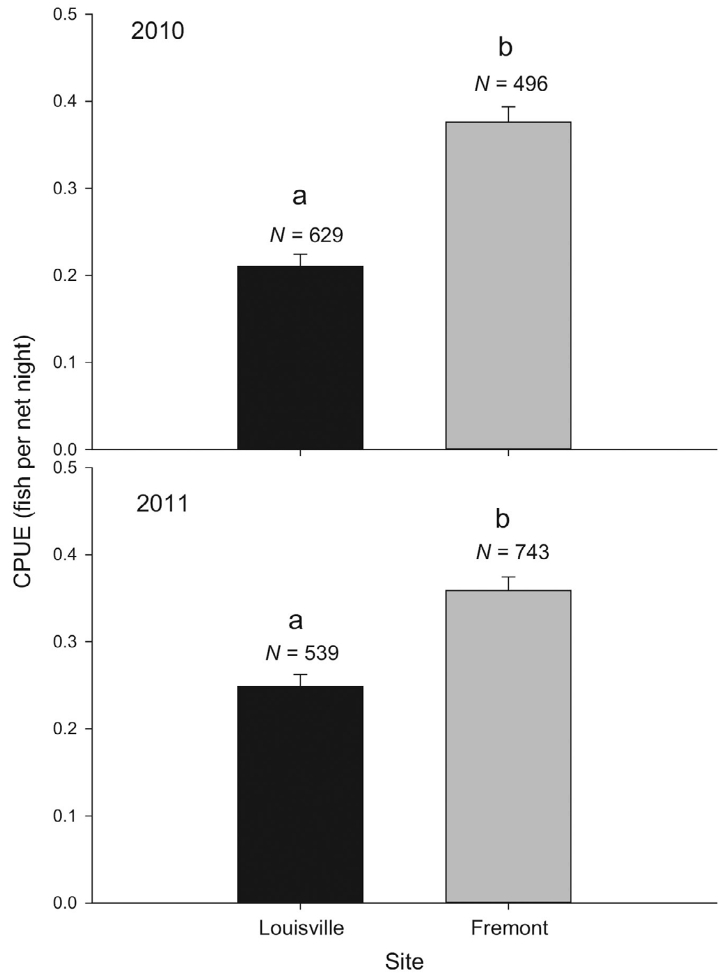

Figure 3. Mean catch rate (CPUE) for channel catfish ≥200 mm collected with hoopnets in the Platte River, Nebraska, in 2010 and 2011. Error bars represent *SE*. Different letters denote significant differences ($p < .05$) between sites in each year. Total hoopnet deployments are shown above bars.

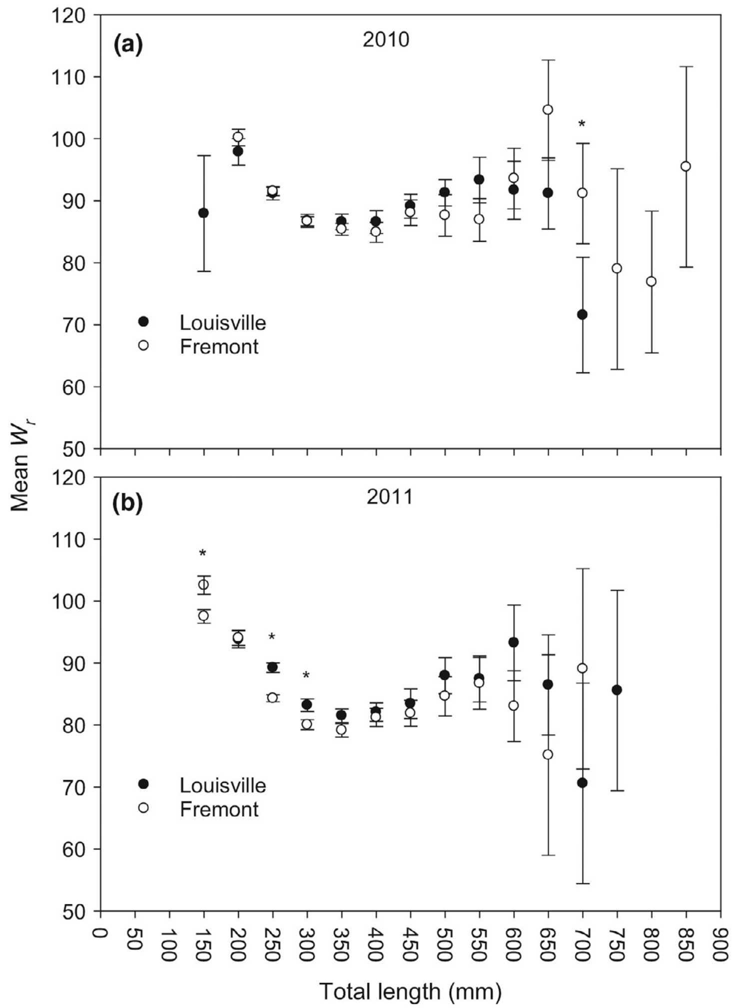

Figure 4. Mean relative weight (W_r) of channel catfish by 50-mm total length groups collected with hoopnets and electric fishing in 2010 **(a)** and 2011 **(b)** in the Platte River at Louisville and Fremont, Nebraska. Error bars represent *SE*. Asterisks indicate significant differences ($p < .05$) in mean W_r between sites.

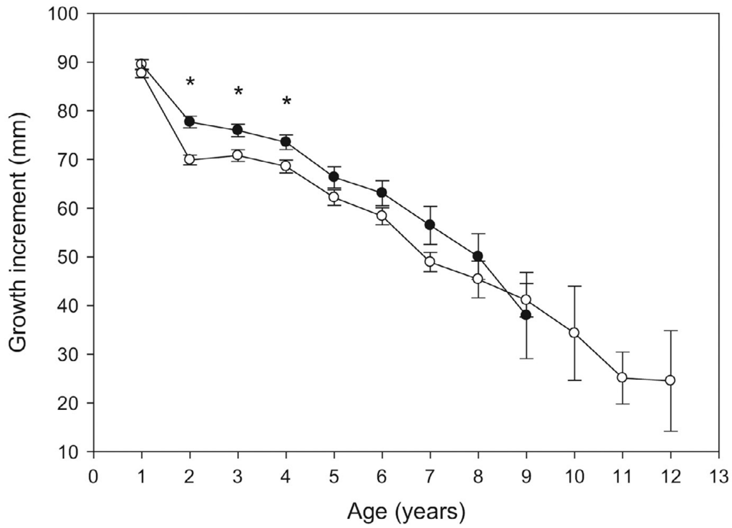

Figure 5. Mean annual growth increment for all ages of channel catfish sampled in the Platte River at Louisville (filled circles) and Fremont (open circles), Nebraska, during 2010 and 2011. Error bars represent *SE*. Asterisks indicate significant differences ($p < .05$) in mean annual growth increments between sites.

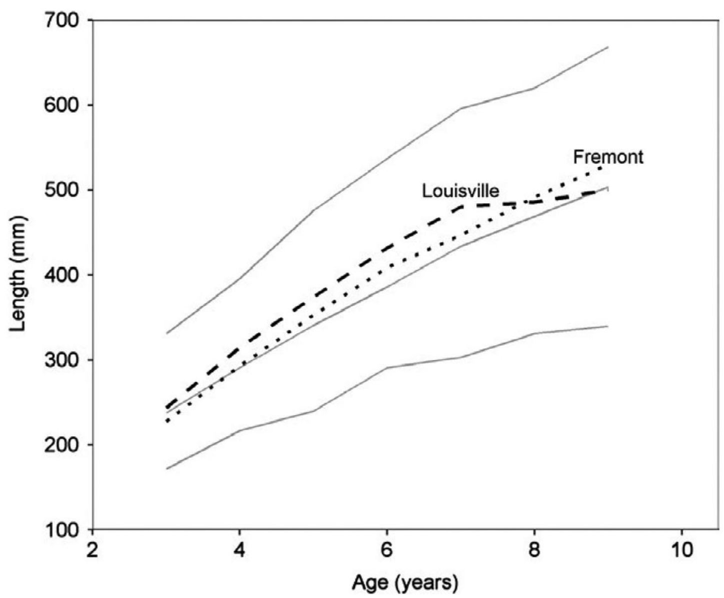

Figure 6. Mean back-calculated total length at age for channel catfish collected in the Platte River at Louisville and Fremont, Nebraska, during 2010 and 2011 compared to standard growth percentiles for channel catfish across their geographic range (grey lines). Standard growth percentiles (25th, 50th and 75th) from Hubert (1999).

Table 1. Comparison of competing models used to describe channel catfish population estimates near Louisville, Nebraska in the lower Platte River from 2010 to 2011.

Model	*AICc*	*Δ AICc*	*WAICc*	*k*
$Ø.\ (\gamma'.) \neq (\gamma''.)\ (p_t) = (c_t)\ (N_{yearly})$	−12899.967	0.00000	0.74485	24
$Ø.\ (\gamma'.) \neq (\gamma''.)\ (p_t) \neq (c_t)\ (N.)$	−12897.107	2.86000	0.17825	42
$Ø.\ (\gamma'.) \neq (\gamma''.)\ (p_t) \neq (c_t)\ (N_{yearly})$	−12895.287	4.68030	0.07174	43
$Ø.\ (\gamma' = 0)\ (\gamma'' = 0)\ (p_t) \neq (c_t)\ (N_{yearly})$	−12888.202	11.76510	0.00208	41
$Ø.\ (\gamma' = \gamma'')\ (p_t) \neq (c_t)\ (N_{yearly})$	−12888.202	11.76510	0.00208	41
$Ø.\ (\gamma' = 0)\ (\gamma'' = 0)\ (p_t) \neq (c_t)\ (N.)$	−12885.042	14.92490	0.00043	40
$Ø.\ (\gamma' = \gamma'')\ (p_t) \neq (c_t)\ (N.)$	−12885.042	14.92490	0.00043	40
$Ø.\ (\gamma' = \gamma'')\ (p_t) = (c_t)\ (N.)$	−12880.515	19.45240	0.00004	22
$Ø.\ (\gamma'.) \neq (\gamma''.)\ (p_t) = (c_t)\ (N.)$	−12880.487	19.48040	0.00004	22
$Ø.\ (\gamma' = 0)\ (\gamma'' = 0)\ (p_t) = (c_t)\ (N_{yearly})$	−12880.461	19.50640	0.00004	22
$Ø.\ (\gamma' = \gamma'')\ (p_t) = (c_t)\ (N_{yearly})$	−12878.739	21.22850	0.00002	23
$Ø.\ (\gamma' = 0)\ (\gamma'' = 0)\ (p_t) \neq (c_t)\ (N_{yearly})$	63618.871	76518.83890	0.00000	20

Models include survival (*Ø*), temporary emigration (γ′ and y″), capture probability (*p*), recapture probability (*c*) and population size (*N*). "Yearly" superscript indicates channel catfish population estimates were allowed to vary by year. Subscript "*t*" indicates the parameter was allowed to vary by time (i.e. year or primary event) and "." indicates the parameter was constant across time. Models are ranked by corrected Akaike's information criterion (AICc; the first row shows the highest-ranking model), where *k* is the number of parameters, ΔAICc is the difference between a model's AICc value and that of the highest-ranked model, and WAICc is the Akaike weight (sum of all weights = 1.00).

Table 2. Comparison of competing models used to describe channel catfish population estimates near Fremont, Nebraska in the lower Platte River from 2010 to 2011.

Model	*AICc*	*AAICc*	*WAICc*	*k*
$Ø.\ (\gamma'.) \neq (\gamma''.)\ (p_t) = (c_t)\ (N_{yearly})$	−22243.6346	0.00000	0.88009	19
$Ø.\ (\gamma'.) \neq (\gamma''.)\ (p_t) = (c_t)\ (N.)$	−22239.6307	4.00390	0.11887	18
$Ø.\ (\gamma'.) \neq (\gamma''.)\ (p_t) \neq (c_t)\ (N_{yearly})$	−22228.8723	14.76230	0.00055	33
$Ø.\ (\gamma' = 0)\ (\gamma'' = 0)\ (p_t) = (c_t)\ (N_{yearly})$	−22227.3267	16.30790	0.00025	17
$Ø.\ (\gamma' = \gamma'')\ (p_t) = (c_t)\ (N_{yearly})$	−22226.4377	17.19690	0.00016	18
$Ø.\ (\gamma'.) \neq (\gamma''.)\ (p_t) \neq (c_t)\ (N.)$	−22224.9172	18.71740	0.00008	32
$Ø.\ (\gamma' = 0)\ (\gamma'' = 0)\ (p_t) \neq (c_t)\ (N_{yearly})$	−22216.1959	27.43870	0.00000	31
$Ø.\ (\gamma' = \gamma'')\ (p_t) = (c_t)\ (N.)$	−22215.4467	28.18790	0.00000	17
$Ø.\ (\gamma' = \gamma'')\ (p_t) \neq (c_t)\ (N_{yearly})$	−22214.1682	29.46640	0.00000	32
$Ø.\ (\gamma' = 0)\ (\gamma'' = 0)\ (p_t) = (c_t)\ (N.)$	−22213.6245	30.01010	0.00000	16
$Ø.\ (\gamma' =0)\ (\gamma'' = 0)\ (p_t) \neq (c_t)\ (N.)$	−22203.0025	40.63210	0.00000	30
$Ø.\ (\gamma' = \gamma'')\ (p_t) \neq (c_t)\ (N.)$	−22201.9709	41.66370	0.00000	31

Models include survival (*Ø*), temporary emigration (γ′ and y″), capture probability (*p*), recapture probability (*c*) and population size (*N*). "Yearly" superscript indicates channel catfish population estimates were allowed to vary by year. Subscript "*t*" indicate the parameter was allowed to vary by time (i.e. year or primary event) and "." indicated the parameter was constant across time. Models are ranked by corrected Akaike's information criterion (AICc; the first row shows the highest-ranking model), where *k* is the number of parameters, ΔAICc is the difference between a model's AICc value and that of the highest-ranked model, and WAICc is the Akaike weight (sum of all weights = 1.00).

Table 3. Incremental proportional size distribution indices for stock (≥280 mm total length [TL]) to quality (≥410 mm TL;PSD S-Q), quality to preferred (≥610 mm TL; PSD Q-P) and quality to memorable (≥710 mm TL;PSD P-M) sizes of channel catfish in the Platte River at Louisville and Fremont, Nebraska during 2010 and 2011 Values in parentheses are 95% confidence intervals.

Location	*N*	*PSD S-Q*	*PSD Q-P*	*PSD P-M*
Louisville	7,044	80 (78–82)	19 (17–21)	1 (1–2)
Fremont	4,036	84 (81–86)	15 (13–17)	1 (0–2)

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