Notes

Detection Probabilities of Flathead Catfish in Small Kansas Impoundments

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Abstract

A primary challenge of Flathead Catfish *Pylodictis olivaris* management is uncertainty associated with sampling strategies and resulting ambiguity in population-level information. Assessment of impoundment and environmental conditions that affect detection probability may aid in reducing sample variance and benefit inferences regarding changes to Flathead Catfish populations. We sampled eight small impoundments in Kansas (37–114 surface ha) using low-frequency electrofishing in summer, 2021. We revisited sites nine times over three months using an occupancy modeling framework to estimate the influence of impoundment and environmental conditions on detection probability of Flathead Catfish. We employed an information theoretic approach and ranked models built with impoundment as a random effect and three environmental variables predicted to influence detection of Flathead Catfish in small impoundments. Detection probability across all populations was 0.526 (SE = 0.020) and was influenced by water temperature, mean depth of the impoundment, and proportion of impoundment sampled. Generally, detection probability increased with all measured variables. The inclusion of detection probability in assessments of Flathead Catfish in small impoundments can inform interpretation of catch-related metrics. Further, variable detection suggests collection of multiple samples during a defined sampling period might be more suitable for characterizing populations than a single sample.

Keywords: Ictaluridae; population monitoring; *Pylodictis olivaris*

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Introduction

Flathead Catfish *Pylodictis olivaris* are native to the Mississippi, Mobile, and Rio Grande River drainages in the United States (Jackson 1999). The species is considered an apex predator because of attainment of large size (up to 55 kg) and piscivorous feeding strategy (Jackson 1999; Bonvechio et al. 2009; Flowers et al. 2011; Schmitt et al. 2019). These traits contribute to Flathead Catfish supporting popular recreational fisheries throughout their distribution (Arterburn et al. 2002; Montague and Shoup 2021). Widespread stockings of Flathead Catfish have occurred both inside and outside of their native range to increase angling opportunity and provide biological control of undesirable fish populations (Jackson 1999; Haas et al. 2001; Vrtiska et al. 2003; Kwak et al. 2006; Kaeser et al. 2011). In the Atlantic slope drainage, introductions of Flathead Catfish have resulted in established populations that have demonstrated dynamic dispersal behavior and deleterious effects to native fish assemblages (Thomas 1995; Bonvechio et al. 2011; Bonvechio et al. 2016; Hilling et al. 2019; Smith et al. 2021). Obtaining precise population-level data can benefit management plans whether directed at recreational angling or population suppression.

Sampling efficiency has historically limited data collection and subsequent analysis of Flathead Catfish populations (Jackson 1999; Bodine et al. 2013; Montague and Shoup 2021). As such, directed management of Flathead Catfish populations has been uncommon (Michaletz and Dillard 1999; Arterburn et al. 2002; Montague and Shoup 2021). However, recent studies have demonstrated that refined sampling approaches, including different gear combinations, can provide sufficient data for informing management plans for fisheries in rivers and large reservoirs (Ford et al. 2011; Montague and Shoup 2021). Various study designs and modeling approaches have also been used to characterize populations and estimate impacts from harvest regulations and other management strategies in rivers and large impoundments (Makinster and Paukert 2008; Bodine et al. 2016; Muhlbauer and Krogman 2021; Oliver et al. 2021; Montague and Shoup 2022). Nevertheless, there exists knowledge gaps related to environmental variables associated with detection probability and subsequent catch rates (Montague and Shoup 2021). Specifically, uncorrected sampling biases (e.g., detection probability) may misrepresent the sampled population and result in management actions that may be deleterious to populations or have limited effect.

Flathead Catfish populations have been sampled in diverse aquatic systems with a variety of gear types, and recent studies have suggested low-frequency electrofishing as the most efficient sampling gear (Stauffer and Koenen 1999; McCain et al. 2011; Bodine et al. 2013; Montague and Shoup 2022). However, the relative influences of location-specific and environmental factors on detection probability are largely unknown (Bodine et al. 2013; Montague and Shoup 2021). Quantification of factors influencing the probability of detection for Flathead Catfish in small impoundments can aid in further development of study designs (e.g., when and where to sample) that reduce bias and provide greater confidence in implementation of management actions. Detection probability is typically estimated using study designs that incorporate temporally replicated samples where population closure is assumed (e.g., occupancy models and closed or open-population mark-recapture models; Coggins et al. 2014; Sutherland and Linden 2019). Site, environmental, and individual covariates (e.g., water quality, season, fish length) that influence detection are often identified in these models (Hayer and Irwin 2008; Stewart and Long 2016). Quantifying detection probability of a species to a sampling gear among different aquatic systems with varying characteristics can allow researchers to better understand biases and refine sample plans accordingly. As such, the objective of this study was to examine the influence of site and environmental factors on detection probability of Flathead Catfish using low-frequency electrofishing.

Study Sites

We selected eight small eastern Kansas impoundments between 37 and 114 ha (mean = 63 ha) based on presence of a Flathead Catfish population and proximity to a management office for examination. Each impoundment was created in the mid to late 1900s and managed primarily for recreational angling. Mean depths ranged from 2.0–6.6 m across the eight impoundments. Anecdotally, physical habitat was similar in all impoundments and included a lacustrine zone near the dam, a degraded thalweg, and shoreline habitat that included revetted rock and brush piles. Species composition included Largemouth Bass *Micropterus salmoides*, Channel Catfish *Ictalurus punctatus*, crappies *Pomoxis* spp., Bluegill *Lepomis macrochirus*, Gizzard Shad *Dorosoma cepedianum*, and Flathead Catfish in all impoundments.

Methods

Estimating detection probability often requires repeat surveys at a sample location under the assumption of

Table 1. Ranking of all subset occupancy models to estimate detection probability of Flathead Catfish *Pylodictus olivaris* in eight small Kansas impoundments from July to September 2021. Occupancy (psi) was fixed in all models but detection probability (p) was allowed to vary in response to scaled mean depth of the impoundment (depth), proportion of impoundment sampled (samp), and water temperature at the time of sample collection (temp). Coefficients are presented with standard error in parentheses.

psi(int)	p(int)	p(depth)	p(samp)	p(temp)	df	logLik	AICc	ΔAICc	weight
2.28	–2.13	0.25 (0.09)	1.91 (0.83)	0.20 (0.08)	6	–466.06	945.23	0.00	0.48
2.26	–1.12	0.27 (0.11)		0.20 (0.09)	5	–468.13	947.03	1.80	0.20
2.28	–2.08	0.25 (0.09)	1.86 (0.83)		5	–468.79	948.36	3.13	0.10
2.26	–1.16		2.05 (1.16)	0.20 (0.09)	5	–469.05	948.88	3.65	0.08
2.25	0.01			0.20 (0.09)	4	–470.36	949.23	4.01	0.07
2.26	–1.10	0.26 (0.11)			4	–470.77	950.06	4.83	0.04
2.26	–1.13		2.01 (1.15)		4	–471.71	951.93	6.70	0.02
2.25	0.02				3	–472.99	952.28	7.05	0.01

population closure (MacKenzie et al. 2017). We selected 8–15 fixed sample sites from each impoundment based loosely on impoundment size that consisted of areas with brush piles, revetted-rock shoreline, or depth transition areas with firm substrate based on previous study assessing habitat use by Flathead Catfish (Weller and Winter 2001). We maintained a minimum of 200 m spacing between sites to retain site independence. We sampled three times monthly from July to September 2021 and separated within-month samples by a minimum of 7 d to allow a recovery period (Montague et al. 2023). In total, each fixed sample site was sampled nine times. We used low-frequency electrofishing (i.e., 15 Hz, 25% duty cycle) for five minutes with standardized power output based on water conductivity (Miranda 2009; Bodine et al. 2013). We maintained the electrofishing boat at a single position for a minimum of two minutes prior to slowly pursuing affected fish within an approximate 100-meter radius. A single netter on the bow of the electrofishing boat and one or two netters on the bow of the chase boat captured affected fish. We measured total length (TL; mm) and weight (g) from collected Flathead Catfish. Any biases associated with targeted habitat sampling and maintaining fixed sites throughout the study were expected to be minimal given the area of the sample, ~3.14 ha given an effective 100-meter sampling radius (Bodine et al. 2013; Montague et al. 2023), and the spatial allocation of samples within each small impoundment. More specifically, sampling effort on average covered 58% of the total surface area of the small impoundments assessed.

We assessed detection probability using single-season occupancy models with assumed population closure (i.e., no mortality, recruitment, emigration, or immigration) during surveys (Schloesser et al. 2012; Sutherland and Linden 2019). Our primary interest was variation in detection probability stemming from select site and environmental covariates measured at each reservoir. We used impoundment as a random effect, two site covariates, and one survey covariate to build mixed-effect occupancy models (Data S1, Supplemental Material). Site covariates included mean depth of the impoundment based on previous bathymetric surveys and proportion of impoundment sampled. The survey covariate was water temperature as measured by a boat-mounted chartplotter and was scaled for analyses (Sutherland and Linden 2019). The latent variable of occupancy was of limited interest and, as such, was modeled as a constant value without covariates (Schloesser et al. 2012). All subset models that included different combinations of the covariates were fit to the survey data and ranked using Akaike's information criteria corrected for small sample sizes (Burnham and Anderson 2002). Detection probability analyses and subsequent model selection were conducted using base functions, the unmarked package, and the MuMIn package in R version 4.2.1 (Fiske and Chandler 2011; Bartón 2022; R Core Team 2022; Kellner et al. 2023).

Results

Overall, we conducted 62.25 hours of electrofishing and captured 768 Flathead Catfish across 83 sites among the eight study impoundments. The top-ranked occupancy model suggested detection probability varied by water temperature, mean depth, and proportion of waterbody sampled (Table 1). A second model within two AICc values suggested water temperature and mean depth, but not proportion of waterbody sampled, were important predictors of detection. Detection probability across all populations without the influence of environmental covariates was 0.526 (SE $=$ 0.020) and generally increased with water temperature, mean depth, and proportion of the impoundment that was sampled (Figure 1).

Discussion

Detection of Flathead Catfish during sampling events has been identified as a primary factor limiting comparisons of populations across space and time (Bodine et al. 2013; Montague and Shoup 2021). Detection probabilities observed in our study were much greater than estimated for three Oklahoma populations ($<$ 0.10; Montague and Shoup 2022). However, there were several differences between the two studies that may have influenced detection. Impoundments sampled in Oklahoma were larger (102–1364 ha; Montague and Shoup 2022) than those sampled in the current study (37–113 ha). Additionally, Montague and Shoup (2022) sampled the entire shoreline using a semi-mobile, stratified random approach without use of a chase boat. This contrasts with our approach of sampling fixed sites in both littoral and pelagic areas of

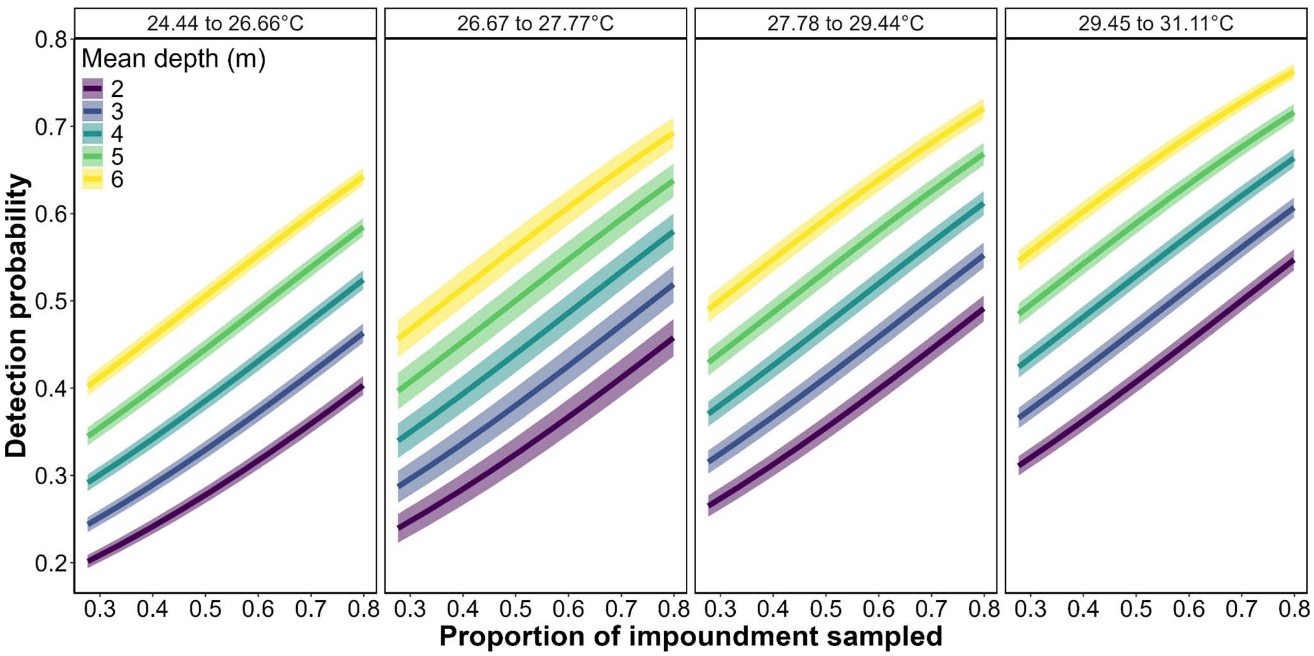

Figure 1. Estimated detection probability of Flathead Catfish *Pylodictus olivaris* from eight small Kansas impoundments using low-frequency electrofishing from July to September 2021. Panels represent quantiles of water temperature observed during the study and estimates at five water depths are presented with one standard error. Proportion of impoundment sampled is displayed on the x-axis for all panels. These three covariates (water temperature, mean depth of the impoundment, and proportion of impoundment sampled) were present in the most parsimonious detection probability model.

each impoundment with a nearly stationary electrofishing boat and relying on a chase boat to capture surfacing fish. Aside from data collection differences, there were also differences in how data were analyzed. For example, Montague and Shoup (2022) estimated detection probability using Cormack-Jolly-Seber models whereas we used an occupancy model approach. Another factor that may influence detection in either study is not meeting the assumption of population closure. If high levels of mortality or recruitment occurred during the study period, detection estimates would be biased (Sutherland and Linden 2019). Any of these factors could plausibly affect detection estimates and highlight the importance of refining sampling methodology to understand inherent biases.

Effects of water temperature, mean depth, and proportion of impoundment sampled were influential in detection of Flathead Catfish in this study. Specifically, detection was greatest when water temperature was elevated, mean impoundment depth was greater, and a greater proportion of an impoundment was sampled. Inclusion of water temperature in our model corroborates findings from three Oklahoma Flathead Catfish populations that suggested capture probability was influenced by water temperature and catch efficiency was greatest when water temperature was $> 24^{\circ}$ C (Montague and Shoup 2022). However, we did not conduct any samples when water temperature was $< 24^{\circ}$ C or $> 31^{\circ}$ C so the comparisons to the Oklahoma studies are constrained. Mean depth of impoundment likely served as a proxy for habitat complexity and associated Flathead Catfish abundance (Kovalenko et al. 2012). Detection probability has been positively related to population abundance for several plant and animal species including fishes corroborating our findings (McCarthy et al. 2013; Pritt et al. 2014). The influence of sampling effort (i.e., spatial coverage) has also been positively related to detection probability of several fish species as observed in our study (Reid and Haxton 2017). Our results coupled with those presented from other studies demonstrate that detection probability of Flathead Catfish is expected to be influenced by site or survey characteristics. Variation in Flathead Catfish detection may occur across the geographic extent of Flathead Catfish populations given heterogeneity of occupied systems. Inherent variability across systems highlights the importance of considering detection probability when conducting population assessments that likely have imperfect detection.

Intricacies relating to sampling and understanding Flathead Catfish populations have long created management difficulties (Bodine et al. 2013; Montague and Shoup 2021). However, continual refinement of sampling gears and analytical techniques have helped researchers better characterize populations to make informed management decisions (e.g., harvest regulations; Muhlbauer and Krogman 2021). These data coupled with findings from Montague and Shoup (2022) suggest studies may benefit from repeat sampling of Flathead Catfish populations to mitigate daily influences on detection. For example, managers may wish to conduct multiple samples when water temperature is between 24° C and 31°C to encompass a range of water temperature conditions rather than characterizing a population with a single-day sample. Alternatively, care could be taken to collect monitoring samples when influential environmental conditions are stable to minimize effects on detection. Additionally, there was evidence that more effort expended during sampling (i.e., proportion of impoundment sampled) was positively related to detection. Consideration of these sources of variability, and others not yet examined, can aid managers in development of sampling strategies for informed management of Flathead Catfish populations.

Supplemental Material

Please note: The *Journal of Fish and Wildlife Management* is not responsible for the content or functionality of any supplemental material. Queries should be directed to the corresponding author for the article.

Reference S1. Smith CT, Reid SB, Godfrey L, Ardren WR. 2011. Data from: Gene flow among Modoc sucker and Sacramento sucker populations in the upper Pit River, Journal of Fish and Wildlife Management, 2(1):72–84. Archived in Dryad Digital Repository: https://doi.org/10.5061/dryad.8433

Data S1. Flathead Catfish *Pylodictis olivaris* data collected from June to September 2021 from eight small Kansas impoundments. These data include impoundment, sample site, number of Flathead Catfish sampled on each sampling trip (obs1:obs9), proportion of the impoundment sampled (prop_samp), mean depth of the impoundment (mean_depth), and water temperature during each sampling trip (temp1:temp9). Data are formatted for construction of occupancy models using the unmarkedFrameOccu function in the unmarked package in R version 4.2.1 (Fiske and Chandler 2011; R Core Team 2022).

Code A1. GitHub repository containing data and R code used to analyze data and create tables and figures.

Available: https://doi.org/10.3996/JFWM-23-057. https://github.com/bencneely/FCF_detection_JFWM

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