Assessment of Iowa's Shovelnose Sturgeon Sport Fisheries

Study 7047 Completion Report
Federal Aid to Sport Fish Restoration
Iowa Fisheries Research

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WILDLIFE & SPORT FISH RESTORATION

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STUDY 7047

Assessment of Iowa's Shovelnose Sturgeon sport fisheries

OBJECTIVE

By the year 2019, assess shovelnose sturgeon sampling methods, population dynamics (size structure, age, growth, mortality, spawning periodicity), and movement in Iowa rivers and provide management recommendations.

APPROACH 1

Standard sampling protocols for Shovelnose Sturgeon

OBJECTIVE

Assess different gear types and review pertinent literature to develop a standard sampling protocol for Iowa's Shovelnose Sturgeon fisheries.

APPROACH 2

Evaluate Shovelnose Sturgeon population demographics

OBJECTIVE

Determine size structure, age, growth, mortality, spawning periodicity, and movement of Shovelnose Sturgeon populations in Iowa rivers.

APPROACH 3

Completion report and management guidelines

OBJECTIVE

Compile, analyze, and publish results in federal aid reports, peer-reviewed and lay journals as appropriate.

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Executive Summary

Shovelnose Sturgeon provide an important recreational and commercial fishery for the Upper Mississippi River (UMR) and recreational fisheries in associated tributaries (e.g., Cedar and Des Moines rivers). However, Shovelnose Sturgeon distribution and abundance have been reduced over the last century due to habitat modifications and overharvest. Despite popularity and historical declines, limited population demographic and sampling efficiency information exists on Shovelnose Sturgeon populations in the UMR and associated tributaries. Thus, the objectives of this study were to 1) evaluate methods to sample Shovelnose Sturgeon in tributaries and 2) evaluate population demographics of the UMR and associated tributaries. Major findings from this research were as follows:

- Trammel netting was the most consistent gear with the lowest variation in catch, thus the fewest samples to gain estimates in relative abundance are required compared to electrofishing and trawling. Trammel netting also captured the widest size range of fish and most proportionate male:female ratio. It is suggested that trammel netting be used as a standard gear when objectives are to monitor annual relative abundance and sex ratio.

- Electrofishing and trawling provided higher efficiency (e.g., catch/day) than did trammel netting, thus when sampling objectives require a large number of fish (e.g., to mark as many fish as possible to input into mark-recapture models), a multitude of gears is appropriate.

- Given otter trawling in the UMR- Pool 13 captured a greater number of smaller individuals, including young of year fish, it is suggested to use this as a standard gear for monitoring natural reproduction and recruitment in the Upper Mississippi River.

- Smaller fish were largely absent from sampling in the Cedar and Des Moines rivers, thus further investigation into gears and sampling locations is suggested. Because these tributaries contain suspected spawning congregations, and larval *Scaphirhynchus* spp. are known to drift for hundreds of river kilometers, these smaller fish may not be present in primary sampling location. Otter trawling efforts in UMR-Pool 13 further support this hypothesis.

- Further investigation is also suggested into seasonal differences in gears and how environmental variables (e.g., discharge, water levels, and turbidity) and differing habitats (e.g., depth, velocity, and substrate) affect sampling efforts.

- Growth of Shovelnose Sturgeon in the Cedar River was very slow (~3 mm/year) once individuals reached asymptotic length (~550 mm). Due to slow growth rates observed and the inability to age fish accurately, development and validation of a mark- recapture growth model to determine if this is a viable method to calculate population dynamic rate functions is suggested.

- Due to the lack of small fish collected in tributaries, an investigation into tributary and UMR dynamics and use of Shovelnose Sturgeon throughout multiple life stages (e.g., larval, immature, and mature adults) is suggested (e.g., telemetry, microchemistry, and/or sampling and tagging fish in new locations).

- Further monitoring and evaluation of the regulation change on the UMR is suggested to determine long term effectiveness.

- It is also suggested to continue to work with interconnected state agencies (e.g., Illinois) to continue to develop consistent regulations and management strategies.

Approach 1: An Evaluation of Standard Sampling Protocols for Shovelnose Sturgeon

INTRODUCTION

Sturgeon stocks (family Acipenseridae) throughout the world have experienced population declines due to habitat modifications and overharvest (Birstein 1993). Further, due to the collapse of Caspian Sea sturgeon populations, an increase in harvest pressure has been placed on North American caviar bearing species (e.g., Shovelnose Sturgeon and Paddlefish; Pikitch et al. 2005). Within the Mississippi River there are three species of Sturgeon: Pallid Sturgeon, Shovelnose Sturgeon, and Lake Sturgeon. Of those, only Shovelnose Sturgeon can be legally harvested. Within the Upper Mississippi River (UMR), there is both recreational and commercial harvest while within the UMR's connected tributaries (e.g., Cedar, Des Moines, and Maquoketa rivers) popular recreational fisheries exist. Shovelnose Sturgeon are the smallest of the species, but have similar k-selected life history traits as the other Sturgeon spp. (Birstein 1993; Keenlyne 1997; Billard and Lecointre 2001). Although still abundant, Shovelnose Sturgeon distribution and abundance have been reduced over the last century (Keenlyne 1997). Because of their susceptibility to overharvest, it is imperative to gain the appropriate population level information to properly manage the species for future generations.

Using the most effective method to capture the target species and obtain the most representative size distribution is important to garner appropriate knowledge to monitor and manage fish populations. Numerous gears have been used in various river systems to capture sturgeon within the Mississippi River Basin (Herzog et al. 2005; Kennedy et al. 2007; Killgore et al. 2007; Wanner et al. 2007; Doyle et al. 2008; Phelps et al. 2009; DeVries et al. 2015). Herzog et al. (2005) used small mesh trawls to capture larval *Scaphirhynchus* spp., whereas Kennedy et al. (2007) used a combination of boat electrofishing, gill nets, and benthic trawls to capture adult Shovelnose Sturgeon. Furthermore, Garvey et al. 2009 used monofilament gill nets to capture adult Pallid Sturgeon, Killgore et al. (2007) and DeVries et al (2015) used baited trotlines to capture Pallid Sturgeon, and Koch et al. (2009) drifted trammel nets to capture adult Shovelnose Sturgeon on the Upper Mississippi River. Doyle et al. (2008) and Phelps et al. (2009) provide two comparisons of gear types for sampling Shovelnose Sturgeon in the lower Missouri River and Middle Mississippi River, respectively. Wanner et al. (2007) evaluated precision of catch per unit of effort for passive gillnets, beam trawls, otter trawls, hoop nets, trot lines, and drifted trammel nets to capture juveniles Pallid Sturgeon on the Upper Missouri River among seasons and habitat types. Additionally, the Pallid Sturgeon Population Assessment Program uses a multitude of gears on the Missouri River including: benthic small mesh otter trawls, small mesh push trawls, gillnets, and trot lines to capture adult and young of year *Scaphirhynchus* spp. (Welker and Drobish 2017). However, gear effectiveness for Shovelnose Sturgeon on the Upper Mississippi River and tributary rivers has not been evaluated. Thus, the objective of this study was to evaluate the efficiency and size selectivity of boat electrofishing, drifted trammel netting, and trawling for assessing Shovelnose Sturgeon populations on the Upper Mississippi River and its tributaries in Iowa.

METHODS

Random sampling was conducted via boat electrofishing, drifted trammel netting (years: 2015-2018), and otter trawling (years: 2015-2017) on the Cedar River at Palisades-Kepler State Park during the first two weeks of May annually. This location is suspected to contain multiple spawning sites based on a high concentration of milting males and presence of females with flowing eggs (i.e., likely actively spawning) during previous surveys. Additionally, drifted trammel netting was conducted in Pool 13 near Bellevue, IA (years: 2015 and 2017) and Pool 18 near New Boston, IL (years: 2015, 2017, and 2018) of the Upper Mississippi River during the month of August. Otter trawling in tailwater habitat of the Upper Mississippi River- Pool 13 was conducted from 1993-2019 by the Long Term Resource Monitoring Element following standard sampling protocols outlined in Gutreuter et al. (1995). Boat electrofishing units traveled downstream occasionally varying their speed in relation to current. Output settings varied to maintain operation within the appropriate power goal depending on water conductivity (Miranda 2009). Electrofishing time was recorded for each electrofishing run. Drifted trammel nets were 100-ft in length by 6-ft deep with ½-inch Foamcore float lines and 30-lb. lead core lines. Outer wallings were constructed of number 9 multifilament nylon and were 6-ft deep with 12-in bar mesh. Inner wallings were constructed of number 139 multifilament nylon and were 8-ft deep (hobbled to 6-ft) with 2-in bar mesh. Wooden mules were attached to the ends of nets while drifting to pull them downstream and help prevent them from closing. Drifted trammel nets were set perpendicular to flow and allowed to drift downstream. Time of each drift was recorded. Trawling was conducted with a modified (Missouri) trawl (Herzog et al. 2005). Trawls were deployed and pulled in a downstream direction, typically for three minutes, but time was recorded for each trawl. All captured fish were enumerated and measured to the nearest 1-mm fork length (FL), weighed to the nearest gram, and tagged on a pectoral fin with an individually numbered Monel bird wing tag (Model 1000-3). Sex of each fish was recorded as female (flowing eggs or obvious distended abdomen with large black stripe), male (flowing milt), or unknown.

Standardized catch per unit of effort (SCPUE) was calculated for each gear (e.g., number of fish per average gear deployment time). Average gear deployment time for electrofishing, trammel netting, and otter trawls were 21, 7, and 4 minutes, respectively. Efficiency of each gear was compared by dividing the number of Shovelnose Sturgeon captured by each gear type by the number of boat days the gear was utilized (i.e. three electrofishing boats sampling for two days = 6 boat days). Length frequencies were compared among gears using Kolmogorov-Smirnov (KS) tests (Zar 1984). Coefficient of variation (CV) of CPUE (Zar 1984) was calculated for each gear type to provide a measure of variability among gears. We estimated sample size needed to detect a 25% and 50% difference in mean SCPUE for each gear type using methods described by Allen et al. (1999). Calculations for otter trawling statistics in the Upper Mississippi River- Pool 13 were not calculated due to differences in methodology by the Long Term Resource Monitoring Element of calculating relative abundance.

RESULTS

On the Cedar River, 106 electrofishing runs, 111 trammel net drifts, and 56 trawls were completed, capturing 3020, 2407, and 824 Shovelnose Sturgeon, respectively (Table 1). Mean FL of Shovelnose Sturgeon captured significantly differed between all gears with trammel nets capturing fish with the largest mean FL and electrofishing having the smallest (Figure 1; ANOVA; $F = 178.76$; df = 2, 6,248; $p < 0.01$; Tukey). Length frequencies differed between all gears (Kolmogorov-Smirnov tests, all tests $p < 0.0001$). Trawling and electrofishing crews captured on average 37 and 22 more Shovelnose Sturgeon per sampling day than crews trammel netting, respectively. The percentage of female Shovelnose Sturgeon captured in each gear was significantly different, with electrofishing and trawling capturing a smaller percentage than trammel netting ($\chi^2 = 233.03$; df = 2; $p < 0.00001$). Estimates of mean SCPUE were less variable for trammel nets than electrofishing and trawling. Trammel net sampling required fewer samples than electrofishing and otter trawls to obtain precise estimates of mean SCPUE (Figure 2). Sample size required to estimate mean SCPUE within ±50% difference ranged from ~19 (power = 0.6) to ~46 (power = 0.9) samples for electrofishing and otter trawls, compared to a range of ~13 (power = 0.6) to ~32 (power = 0.9) samples for trammel nets. Sample size required to estimate mean SCPUE within ±25% difference ranged from ~77 (power = 0.6) to ~184 (power = 0.9) samples for electrofishing and otter trawls, compared to a range of ~53 (power = 0.6) to ~128 (power = 0.9) samples for trammel nets.

On the Upper Mississippi River- Pool 13, 624 otter trawls and 126 trammel net drifts were completed (Table 2). On the Upper Mississippi River- Pool 18, 93 trammel net drifts were completed. Trammel netting length frequencies differed between Pool 13 and Pool 18 (Figure 3; Kolmogorov-Smirnov tests, all tests $p < 0.0001$). Trawls in Pool 13 captured the widest size range of fish and a greater proportion of smaller individuals compared to trammel netting. Trammel netting crews captured similar number of Shovelnose Sturgeon per day between Pool 13 and Pool 18. Estimates of mean SCPUE were less variable in Pool 13 than in Pool 18. Trammel net sampling in Pool 13 required fewer samples than in Pool 18 to obtain precise estimates of mean SCPUE (Figure 4). Sample size required to estimate mean SCPUE within ±50% difference ranged from ~21 (power = 0.6) to ~51 (power = 0.9) samples for Pool 13, compared to a range of ~51 (power = 0.6) to ~122 (power = 0.9) samples for Pool 18. Sample size required to estimate mean SCPUE within ±25% difference ranged from ~84 (power = 0.6) to ~202 (power = 0.9) samples for Pool 13, compared to a range of ~204 (power = 0.6) to ~487 (power = 0.9) samples for Pool 18.

DISCUSSION

Based on the results, catch statistics varied among gears. SCPUE for electrofishing was higher than reported for the overall SCPUE on the Upper Wabash River, but lower than reported in an upper reach when efforts were targeted over shallow gravel bars suspected to be spawning habitat (Kennedy et al. 2007). It was not feasible to compare trammel net SCPUE due to differences in methodology of calculating relative abundance (Doyle et al. 2008). Trammel net SCPUE and CV varied between Pool 13 and Pool 18 of the UMR with Pool 13 having a lower CV and SCPUE than Pool 18. This is likely due to environmental conditions (e.g., frequent changes in discharge) in Pool 18 that are not experienced as often in

Pool 13. Otter trawl SCPUE was similar to Kennedy et al. (2007), however their sample was likely skewed based on one large catch and the gear was discontinued due to a high frequency of snags. While SCPUE and fish caught per day was highest for electrofishing, trammel nets provided the lowest CV of SCPUE and thus required the fewest number of samples to detect changes in relative abundance compared to other gear types evaluated. Therefore, fishery managers using trammel nets would expend less sampling effort to obtain reliable estimates of relative abundance. Doyle et al. (2008) determined gillnets required the fewest samples to detect a change in relative abundance in the lower Missouri River and trammel nets required fewer samples than otter trawls. Phelps et al. (2009) also found gillnets produced the highest catch rates for Shovelnose Sturgeon in the Middle Mississippi River. Gillnets were not evaluated in this study as there are not wing dyke structures and associated habitats to set gillnets effectively in the Cedar River.

Reported size structures of Shovelnose Sturgeon across their range are mostly skewed towards larger fish, likely due to sampling gear biases (Quist et al. 1998; Jackson 2004; Kennedy et al. 2007; Koch et al. 2009). Wanner et al. (2007) determined gill nets, trammel nets, and otter trawls likely captured the size structure of the Pallid Sturgeon population. Doyle et al. (2008) and Phelps et al. (2009) found that benthic trawls were most effective at catching juvenile Shovelnose Sturgeon. However, in the Cedar River otter trawls only captured fish 336 mm and greater. Trammel nets captured the widest size range of fish, as well as provided a more proportionate female:male ratio. Electrofishing provided a similar size range to trammel nets however provided a smaller mean length and a sex ratio skewed towards males, similar to Kennedy et al. (2007). It is hypothesized that this is likely due to the inability of electrofishing to sample deep water habitats where females are staging to move to shallow bars used for spawning where males are congregated. One possibility as to why a greater number of smaller fish were not collected could be due to larval drift of Shovelnose Sturgeon out of the study area and individuals not moving back into the study area until reaching maturity (Kennedy et al. 2007). Braaten et al. (2008) estimated average larval drift of Shovelnose Sturgeon and Pallid Sturgeon larvae was 94-250 and 245-530 rkm respectively, however this should be evaluated in tributaries in the future to confirm and examine differences. Trawls in Pool 13 captured a greater proportion of smaller individuals further supporting this hypothesis, as well as the ability of otter trawls to capture smaller individuals more effectively than other gears.

Specific objectives should dictate gears being used. If goals are to evaluate trends in relative abundance, male:female ratio, and spawning periodicity of females with the least amount of effort trammel nets appear to be best suited. If the goal is to capture as many fish as possible to gain growth parameters through mark-recapture analysis, a multitude of gears could be used. However, to refine growth parameters smaller fish are needed to be input into the model, thus other gears (e.g., small mesh otter trawls) or sampling locations may need to be investigated in the future (Herzog et al. 2005; Doyle et al. 2008; Garvey et al. 2009; Phelps et al. 2009). Additionally, in future efforts standardization of runs (e.g., standard run times/locations) for all gear types would be beneficial (Ratcliff et al. 2014).

While this is a thorough review of three gears commonly deployed in Midwestern river systems for sampling Shovelnose Sturgeon, there are other gears that have been used that could be evaluated if current efforts are not reaching specific goals (Herzog et al. 2005; Doyle et al. 2008; Phelps et al. 2009; DeVries et al. 2015). Future efforts to determine how environmental variables (e.g., discharge, water levels, and turbidity) and differing habitats (e.g., depth, velocity, and substrate) affect sampling efforts are warranted. Additionally, investigating seasonal differences in catch statistics may be beneficial to provide a better understanding of how effective these gears are at sampling Shovelnose Sturgeon year round as various gears have demonstrated differences in relative precision and catch rates among different seasons (Wanner et al. 2007; Phelps et al. 2009; DeVries et al. 2015). Additional information on the dynamics between the UMR and tributaries is needed to better understand when and why Shovelnose Sturgeon move into and use interconnected tributaries.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

1. It is suggested that trammel netting be used as a standard gear when objectives are to monitor annual relative abundance and sex ratio. Trammel netting was the most consistent gear with the lowest variation in catch, thus the fewest samples to gain estimates in relative abundance are required compared to electrofishing and trawling. Trammel netting also captured the widest size range of fish and most proportionate male:female ratio,

which may be important considering they are highly migratory and females are targeted for their roe in the Upper Mississippi River. River systems that do not have a predominantly sand substrate may make trammel netting difficult. Managers will have to determine based on riverine habitat and conditions if trammel netting is feasible in rivers other than the Upper Mississippi and Cedar rivers (e.g., Des Moines River).

2. Electrofishing and trawling provided higher efficiency (e.g., catch/day) than did trammel netting, thus when sampling objectives require a large number of fish to be collected (e.g., to mark as many fish as possible to input into mark-recapture models), a multitude of gears is appropriate.
3. Given otter trawling in the UMR- Pool 13 captured a greater number of smaller individuals, including young of year fish, it is suggested to use this as a standard gear for monitoring natural reproduction and recruitment in the Upper Mississippi River.
4. It is suggested to continue to evaluate gears and sampling locations to determine if gears are effective on smaller fish that were largely absent from sampling in the Cedar River near Palisades Kepler State Park. Because this site is a suspected spawning congregation, and larval *Scaphirhynchus* spp. are known to drift for hundreds of river kilometers, these smaller fish may not be present in primary sampling location. Trawling efforts in UMR-Pool 13 further support this hypothesis.
5. Further investigation into seasonal differences in gears and how environmental variables (e.g., discharge, water levels, and turbidity) and differing habitats (e.g., depth, velocity, and substrate) affect sampling efforts is also suggested.

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Table 1. Summary of catch statistics for electrofishing, trawling, and trammel netting in the Cedar River from 2015-2018.

Gear	EF	TW	TN
N	106	56	111
Total Catch	3020	824	2407
SCPUE (SE)	32.5 (2.6)	16.2 (1.8)	22.2 (1.4)
CV	81.9	81.9	68.5
Boat Days	17.5	4.5	15
Catch/day	171	186	149
Mean Length (SE)	588.5 (1.1)	596.8 (2.3)	621.3 (1.4)
Range (mm)	235-834	336-803	230-850
% Males/Unknown	75.8	72.8	56.5
% Females	24.2	27.2	43.5

Table 2. Summary of catch statistics for trawling (years: 1993-2018) trammel netting (years: 2015, 2017) in the Upper Mississippi River- Pool 13 and trammel netting from Upper Mississippi River-Pool 18 (years: 2015, 2017, and 2018).

Location- Gear	Pool 13- TW	Pool 13- TN	Pool 18- TN
N	624	126	93
Total Catch	2203	937	987
SCPUE (SE)	-	9.8 (0.8)	18.2 (2.5)
CV	-	86.0	133.4
Boat Days	-	17	16
Catch/day	-	55	61

Mean Length (SE)	407.5 (2.7)	544.7 (3.3)	621.8 (2.2)
Range (mm)	69-785	164-790	153-837

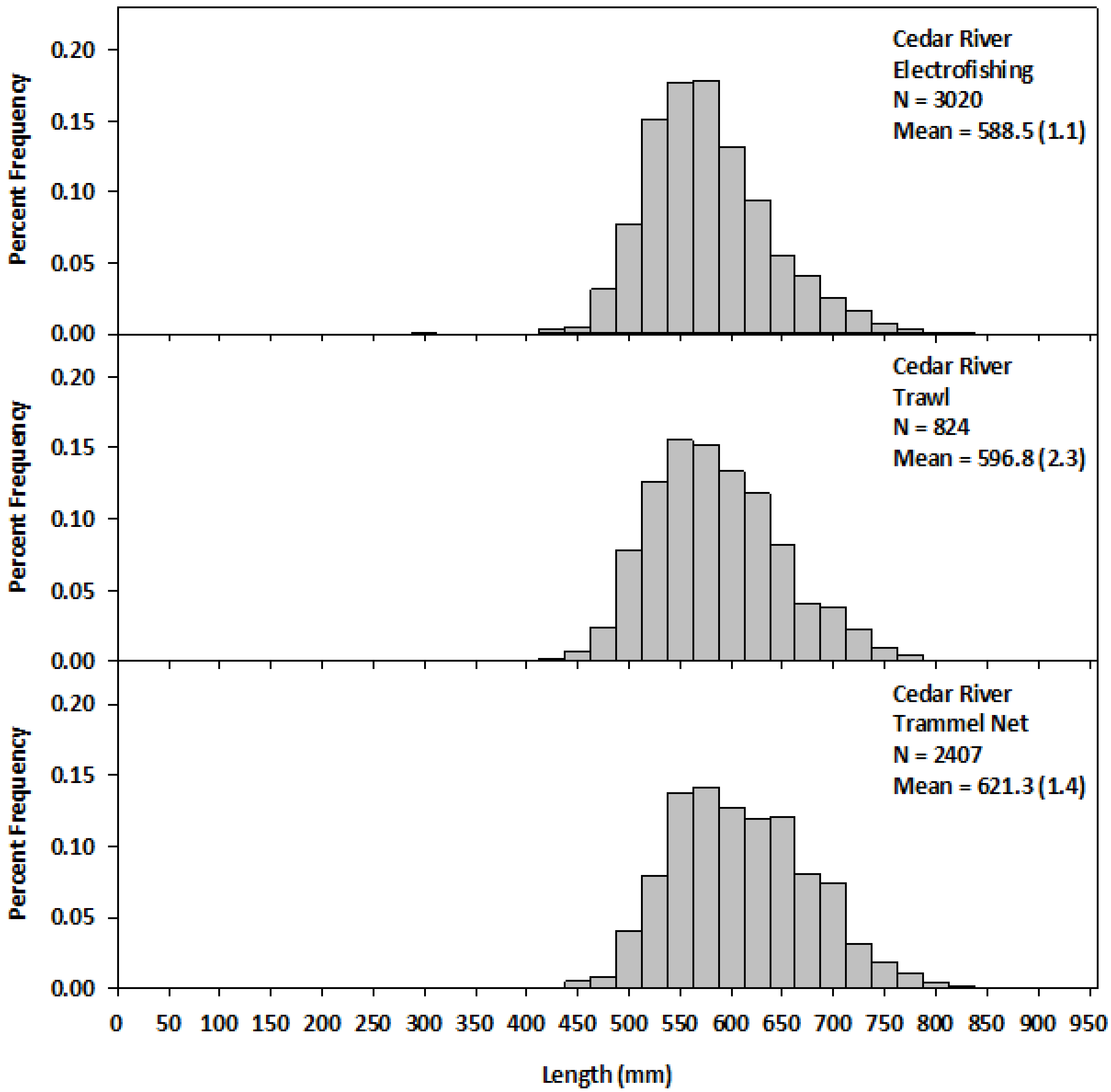

Figure 1. Length frequency distributions with mean length (SE) of Shovelnose Sturgeon collected via electrofishing and trammel netting in the Cedar River from 2015-2018 and otter trawling from 2015-2017. Length frequencies differed between all gears (Kolmogorov-Smirnov tests, all tests $p < 0.001$).

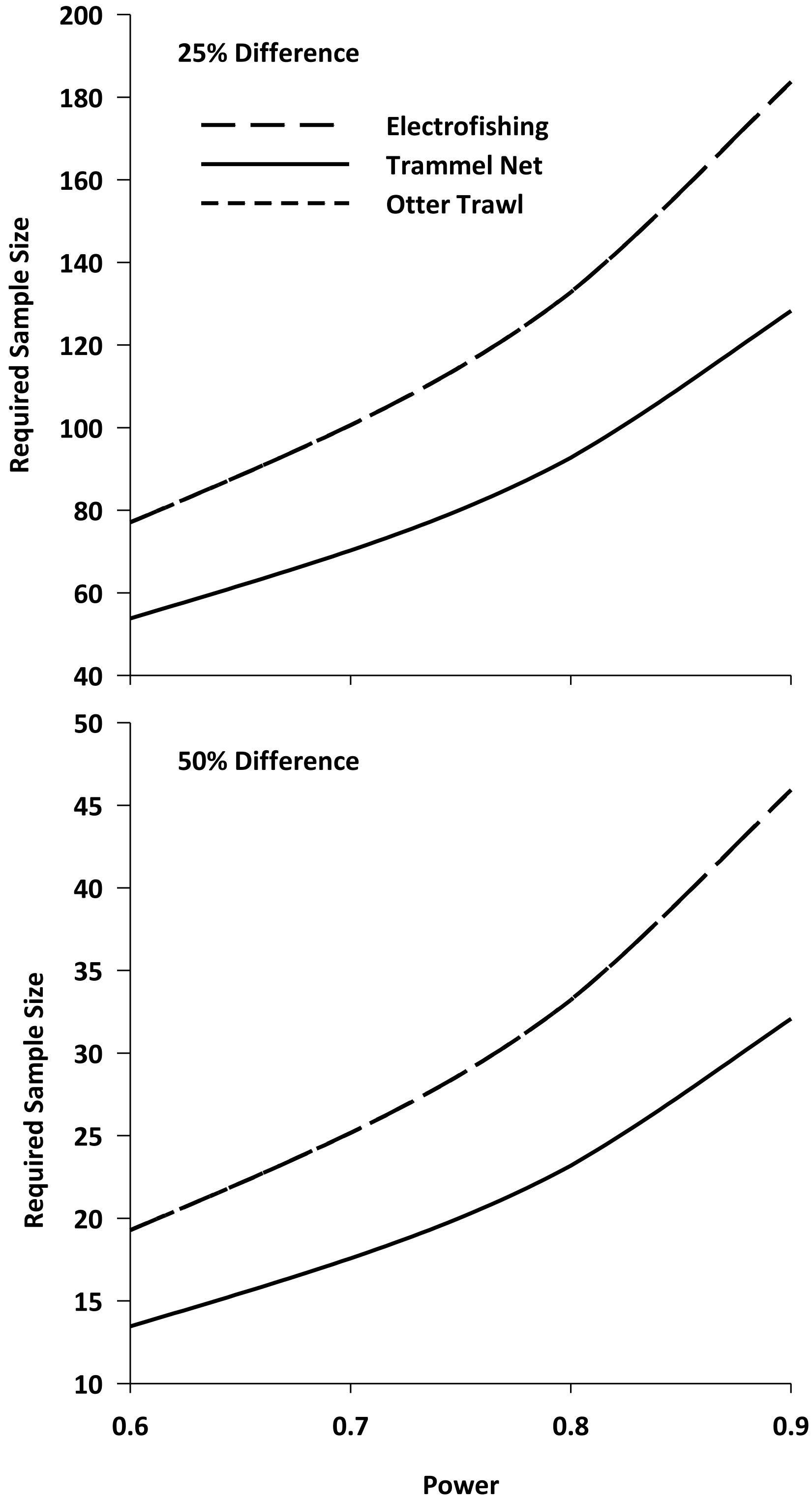

Figure 2. Sample sizes required to detect a 25% (top panel) and 50% (bottom panel) difference in SCPUE at various levels of statistical power (1-β). The alpha level was 0.10 for all sample-size estimates. The required number of electrofishing runs, trammel net drifts, and otter trawls are indicated. Electrofishing and trawling have similar required number of samples, thus are difficult to differentiate in figure.

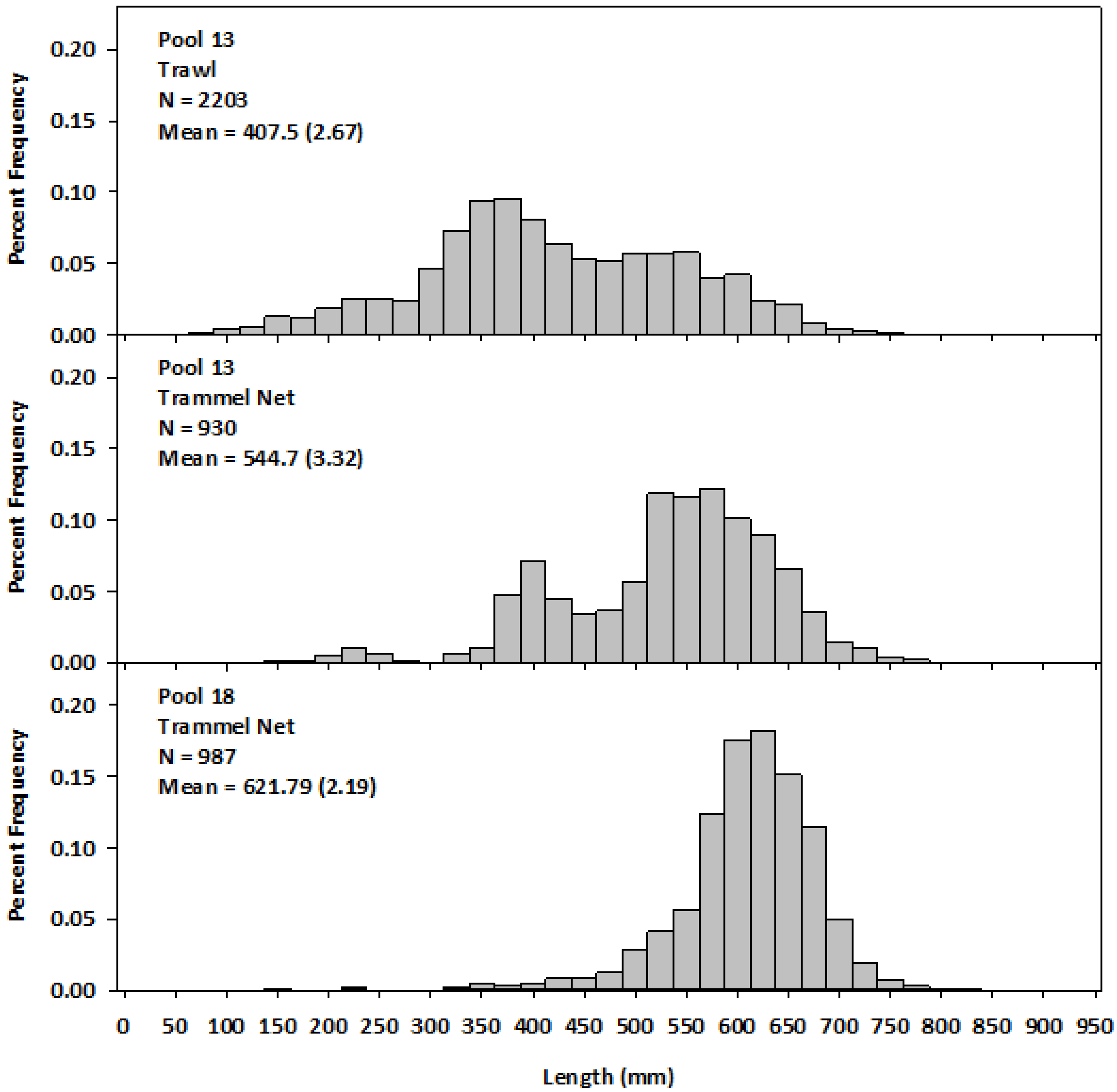

Figure 3. Length frequency distributions with mean length (SE) of Shovelnose Sturgeon collected via trawling in Pool 13 (years: 1993-2019), trammel netting in Pool 13 (years: 2015 and 2017) and Pool 18 (years: 2015, 2017, and 2018) of the Upper Mississippi River.

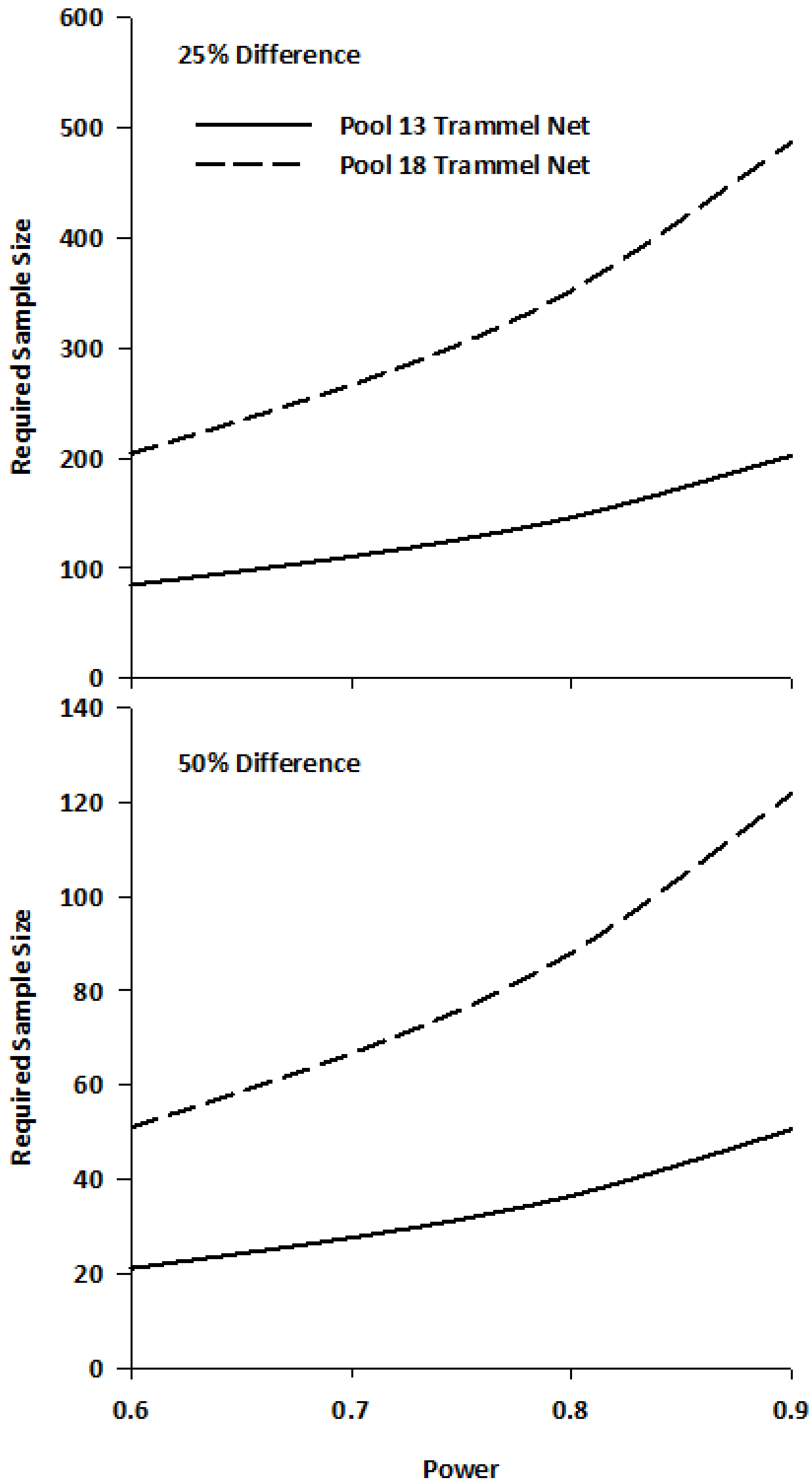

Figure 4. Sample sizes required to detect a 25% (top panel) and 50% (bottom panel) difference in SCPUE at various levels of statistical power (1-β). The alpha level was 0.10 for all sample-size estimates. The required number of trammel net drifts in Pool 13 and Pool 18 of the Upper Mississippi River are indicated.

Approach 2: An Evaluation of Shovelnose Sturgeon Population Demographics in Iowa Rivers

INTRODUCTION

Overfishing has caused the collapse of numerous Caspian Sea sturgeon fisheries, once the main source of world caviar (Pikitch et al. 2005). This has led to increased harvest of domestic stocks of caviar bearing species such as Shovelnose Sturgeon (Koch and Quist 2010). Shovelnose Sturgeon is the most numerous and only Sturgeon spp. in the Upper Mississippi River that still supports both commercial and recreational fisheries. Due to the life history characteristics of Shovelnose Sturgeon (e.g., long-lived, slow growing, late age at maturation, and periodic spawning), they are susceptible to overharvest (Quist et al. 2002, Colombo et al. 2007a, Koch et al. 2009, Tripp et al. 2009). In the Mississippi River below Melvin Price Lock and Dam 26 at Alton, IL, the Shovelnose Sturgeon was listed as threatened under the Endangered Species Act under the similarity of appearance (SOA) clause in 2009 due to the difficulty in reliably differentiating Shovelnose Sturgeon and Pallid Sturgeon using external characteristics. The SOA listing closed commercial harvest of Shovelnose Sturgeon in areas of sympatry with the Pallid Sturgeon (i.e., Mississippi River below Melvin Price Lock and Dam 26, Alton, IL), leaving commercial harvest open on the Upper Mississippi River (UMR) above Lock and Dam 26. This closure has the potential to lead to increased harvest in waters still open to commercial harvest, including Iowa's portion of the UMR (Hintz and Garvey 2012). With this potential increase in harvest pressure it is unknown how it will affect the Shovelnose Sturgeon populations in the UMR and associated tributaries where popular sport fisheries exist.

Historically, Iowa's commercial Shovelnose Sturgeon fishery on the UMR was unregulated. In 2007, concerns regarding increased fishing pressure prompted the Iowa DNR to enact a 27 inch minimum size limit (with a 32" maximum in WI border waters to limit accidental harvest of Lake Sturgeon) and an Oct 15 – May 15 harvest season. A 27 inch minimum length limit was predicted to protect Upper Mississippi River Shovelnose Sturgeon populations from growth and recruitment overfishing while allowing for growth of the fishery (Colombo et al. 2007b; Koch et al. 2009). Illinois commercial Shovelnose Sturgeon fisheries are managed with a 24-32 inch harvest slot limit. Additionally, in 2009 a rule was implemented that made it illegal to possess any Shovelnose Sturgeon less than 27 inches in Iowa waters to help prevent commercial fishers from just using an Illinois license. Modeling indicated that a 24 inch minimum length limit was inadequate to prevent growth and recruitment overfishing under current harvest levels and could lead to stock reduction or collapse (Colombo et al. 2007b; Koch et al. 2009). It is also unknown how commercial harvest on the UMR may adversely affect recreational tributary fisheries. Further, in recent years multiple Midwest rivers (i.e., Wabash, Platte, and lower Des Moines rivers) have experienced summer Shovelnose Sturgeon kills (e.g., Koch and Quist 2010). Specifically, the lower Des Moines River experienced a severe Shovelnose Sturgeon kill during the summer of 2012 with estimates numbers of dead sturgeon exceeding 37,000 (Hupfeld et al. 2015). This fish kill was associated with low flows and high water temperatures (>32° C), further exacerbating the need to study these populations, especially in the face of potential higher water temperatures associated with climate change (Hupfeld et al. 2015).

Popular Shovelnose Sturgeon sport fisheries occur in the Upper Mississippi River (UMR) as well as many tributaries (e.g., Cedar, Des Moines, and Maquoketa rivers) of the UMR. These are generally spring to early summer fisheries that occur in conjunction with spawning migrations. Previous sampling and tagging efforts have documented this movement of sturgeon between the UMR and the associated tributaries, as well as documenting commercial harvest of tributary tagged sturgeon (Iowa DNR, unpublished data). Larger tributaries like the Des Moines and Cedar rivers also likely have resident sturgeon populations. Shovelnose Sturgeon populations are believed to be stable in Iowa, but basic population demographic information for many populations is lacking and they are listed as a species of greatest conservation need in the Iowa Wildlife Action Plan. Koch et al. (2009), Koch and Quist (2010), and Hamel et al. (2015) provide a synopsis of the status and population demographics of Shovelnose Sturgeon throughout their range, largely focused on main stem rivers. However, the dynamics between tributaries and main stem river populations is still poorly understood. Due to the concerns with potential increases in harvest pressure and future mortality events (e.g., fish kills), lack of knowledge of how the main stem UMR populations influence tributary populations, and lack of knowledge on the current population status, understanding basic population demographics (e.g., growth rates, size structure) and life history (e.g., spawning periodicity) of Shovelnose Sturgeon in Iowa rivers is necessary for proper management of these populations to provide a sustainable fishery for future generations. Thus, the objectives of this study were to assess Shovelnose Sturgeon population dynamics (e.g., size structure, age, growth, mortality, spawning periodicity) and movement in Iowa rivers.

METHODS

Sampling was conducted via boat electrofishing, drifted trammel netting, and otter trawling on the Cedar River at Palisades-Kepler State Park (years: 2006-2018) and via boat electrofishing on the Des Moines River near Ottumwa, IA (years: 2015-2018) during the first two weeks of May annually. Additionally, drifted trammel netting was conducted in Pool 13 near Bellevue, IA (years: 2015 and 2017) and Pool 18 near New Boston, IL (years: 2015, 2017, and 2018) of the Upper Mississippi River during the month of August. Otter trawling in tailwater habitat of the Upper Mississippi River-Pool 13 was conducted from 1993-2019 by the Long Term Resource Monitoring Element (LTRM) following standard sampling protocols outlined in Gutreuter et al. (1995). Boat electrofishing units traveled downstream occasionally varying their speed in relation to current. Output settings varied to maintain operation within the appropriate power goal depending on water conductivity (Miranda 2009). Electrofishing time was recorded for each electrofishing run. Drifted trammel nets were 100-ft in length by 6-ft deep with ½-inch Foamcore float lines and 30-lb. Leadcore lead lines. Outer wallings were constructed of number 9 multifilament nylon and were 6-ft deep with 12-in bar mesh. Inner wallings were constructed of number 139 multifilament nylon and were 8-ft deep (hobbled to 6-ft) with 2-in bar mesh. Wooden mules were attached to the ends of nets while drifting to pull them downstream and help prevent them from closing. Drifted trammel nets were set perpendicular to flow and allowed to drift downstream. Time of each drift was recorded. Trawling was conducted with a modified (Missouri) trawl (Herzog et al. 2005). Trawls were deployed and pulled in a downstream direction, typically for three minutes, but time was recorded for each trawl. All captured fish were enumerated and measured to the nearest 1-mm fork length (FL), and weighed to the nearest gram. Sex of each fish in the Cedar and Des Moines rivers were recorded as female (flowing eggs or obvious distended abdomen with large black stripe), male (flowing milt), or unknown. Sex was not recorded on the UMR due the inability to detect differences because of sampling time frame. Sturgeon captured in the Cedar and Des Moines rivers were tagged on a pectoral fin with an individually numbered Monel bird wing tag (Model 1000-3). Recaptures were measured to the nearest mm and weighed to the nearest gram and location was recorded. Growth was evaluated for the Cedar River similarly to Hamel et al. (2014 and 2015) in which they used annual incremental somatic growth (AIG) of Pallid Sturgeon and Shovelnose Sturgeon, respectively. The equation used to develop AIG values is:

$$AIG = \frac{(L_R - L_T)}{(t_R - t_T)/365}$$

For this dataset, AIG was determined as the change in fork length from original tagging date to date of recapture ($L_R - L_T$) divided by the proportion of days between events ($t_R - t_T$) to one year. For fish which had more than one recapture event, the most recent recapture date and length were used. AIG values were plotted by length categories (e.g., 375 mm, 400 mm, 425 mm, etc.) to evaluate growth trends by length.

RESULTS

On the Des Moines River, 2144 Shovelnose Sturgeon were collected via electrofishing with a mean length of 596.7 mm (SE = 1.0; Figure 5). Females and male/unknown sex fish comprised 9.57 and 90.43 percent of fish sampled, respectively. On the Cedar River, Shovelnose Sturgeon were collected via electrofishing (N = 3020), trammel nets (N = 2407), and otter trawls (N = 824) with mean lengths of 588.5 mm (SE = 1.1), 621.3 mm (SE = 1.4), and 596.9 mm (SE = 2.3), respectively). Females and male/unknown sex fish captured via electrofishing, trammel nets, and otter trawls comprised 24.2 and 75.8 percent, 43.5 and 56.5 percent, and 27.2 and 72.8 percent, respectively. On the Upper Mississippi River- Pool 18, 987 Shovelnose Sturgeon were collected via trammel nets with a mean length of 621.79 mm (SE = 2.19; Figure 6). On the Upper Mississippi River- Pool 13, 930 Shovelnose Sturgeon were collected via trammel nets with a mean length of 544.7 mm (SE = 3.32). On Pool 13, 2203 Shovelnose Sturgeon were collected via otter trawls with a mean length of 407.5 mm (SE = 2.67). Annual standardized LTRM trawling catch rates of Shovelnose Sturgeon in Pool 13 have increased substantially since 2011 (i.e., twenty seven year median- 2.8 catch/trawl, 2019- 22.9 catch/trawl; Figure 7).

A total of 1130 recaptures have been recorded, with 753 unique fish on the Cedar River. On average, recaptures occurred 3.48 (.079) years between captures with a maximum time of 11 years. The mean AIG was estimated to be 2.93 mm/year (SE = 0.22) and an asymptotic length of ~ 550 mm (Figure 8). The average margin of measurement error derived from fish measured in the same year as tagging is 0.76 mm (SE = 0.24). The reproductive periodicity interval was shorter for males than for females. A total of 120 males and 114 gravid female Shovelnose Sturgeon were recaptured. Unlike males, few females made spawning migrations in successive years. Peak recoveries for females occurred at 2, 4, and 6 years at large indicating a two year spawning periodicity (Figure 9). However, high recoveries at years 3 and 5 indicated periodicity was likely variable. For males, most recoveries occurred in the second and third years after tagging. However, high returns one year after tagging indicate spawning in successive years, thus likely have a one or two year spawning periodicity. Recaptures based on angler returns and sampling in the Upper Mississippi yielded a total of 30 recaptures. Of those, 6 were recaptured in the Upper Mississippi River. Maximum distance traveled downstream from tagging site on the Cedar River at Palisades-Kepler State Park was ~208 rkm in the Upper Mississippi River- Pool 19 near Burlington, IA. Maximum distance traveled upstream was ~121 rkm near Waterloo, IA, thus a range of movement from tagging site of ~329 rkm (Figure 10).

DISCUSSION

The Des Moines River displayed a slightly larger size structure than the Cedar River. The UMR-Pool 13 exhibited a larger proportion of smaller individuals than any location sampled, including the UMR-Pool 18. The differences in size structure between Pool 13 and Pool 18 may be due to varying levels of commercial harvest between locations. In Pool 18 there may be greater harvest of smaller individuals given the majority of area is located in IL waters with the smaller minimum length limit. A recent increase in natural reproduction and recruitment in Pool 13, likely due to the larger minimum length limit and law prohibiting the possession of fish less than 27 inches in Iowa waters being implemented, may be an additional reason for the differing length frequency distributions. Before implementation of length limit and possession law, there was no minimum length limit. Since the regulation changes, annual standardized trawling catch rates of Shovelnose Sturgeon have increased substantially since 2011 suggesting commercial overharvest of mature females was a factor that was affecting the reduced natural recruitment.

Shovelnose Sturgeon in the Cedar River displayed very slow growth and potentially obtains ages older than previously thought or documented (Quist et al. 2002; Hamel et al. 2014; Hamel et al. 2015). Based on the results, as fish reached sexual maturity, growth slowed substantially. For example, most fish captured above 550 mm exhibited very minimal growth over time. Hamel et al. (2014 and 2015), determined similar growth patterns of Shovelnose Sturgeon and Pallid Sturgeon in the Mississippi and Missouri river basins, including multiple tributaries. Growth of Shovelnose Sturgeon in the Wabash River exhibited a small estimated Brody growth coefficient (K) due to very minimal growth of larger individuals, similar to the Cedar River population (Hamel et al. 2015). Additionally, Hamel et al. (2015) determined the largest and slowest growing populations in the Mississippi River corresponded with areas of no or reduced commercial harvest (Hamel et al. 2015). Given the Cedar River is only subject to recreational harvest, this is not a surprising result. However, given the range of movement discovered from the Cedar River and the lack of younger fish collected compared to the UMR, the influence of the UMR on the Cedar River population warrants further investigation. Spawning periodicity between sexes appeared to be similar to Paddlefish, another long lived, k-selected species (Scarnecchia et al. 2007). Scarnecchia et al. (2007) determined spawning periodicity decreased as Paddlefish aged. Evidence of this in Shovelnose Sturgeon should be investigated in the future.

During the progression of this study it was determined that using fin rays were not a viable method to accurately age Shovelnose Sturgeon to calculate population parameters, similar to Hamel et al. (2014 and 2015). Due to the inability to age Shovelnose Sturgeon accurately, mark-recapture methods to estimate growth and age may be the best course of action to continue to refine population parameters. Mark-recapture methodology to calculate population parameters has been used for numerous species across the world, including Sturgeon spp. and other long lived fishes with difficulties in age estimation (Paragamian and Beamesderfer 2003; de Pontual et al. 2006; Pledger et al. 2013; Hamel et al. 2014; Hamel et al. 2015). There are alternative methods that are also being developed and used to continue to validate and refine predicted age and growth estimates (e.g., carbon dating, alternate tagging methods; Campana et al. 2008; Bruch et al. 2009) and may warrant investigation to develop these parameters for the Cedar River Shovelnose Sturgeon population. Also due to the lack of small fish collected in the Cedar River, an investigation into Cedar River and UMR dynamics and use of Shovelnose Sturgeon throughout multiple life stages (e.g., larval, immature, and mature adults) is suggested. This may be especially important considering both commercial and recreational harvest occurs in the UMR. In order to effectively gain mark-recapture information on smaller and older fish, tags that allow implantation on juvenile sturgeon and the ability of these fish to retain tags for decades should be evaluated. Thus, additional tagging methods (e.g., PIT tags) for juvenile and adult Shovelnose Sturgeon and evaluating long term tag loss of Monel bird wing bands is suggested. Further developing and expanding mark-recapture methodology to other locations (e.g., Des Moines River, UMR, and Maquoketa River) and other long-lived species (e.g., Paddlefish) where age estimation is inaccurate is recommended as well. With the observed life history characteristics (e.g., slow growth rates and periodic spawning) and potential fragility due to overharvest and climate change of these populations, continued monitoring and research (e.g., mark-recapture growth model development and validation, UMR and associated tributaries dynamics, and long term tagging methods) is recommended to advance the knowledge of Shovelnose Sturgeon in the Upper Mississippi River and associated tributaries.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

1. Due to the slow growth of Shovelnose Sturgeon in the Cedar River, and inability to age fish accurately, development and validation of a mark- recapture growth model to determine if this is a viable method to calculate population dynamic rate functions is suggested. To do this, continuation of current sampling and tagging methodology is suggested to develop and refine parameters to be input into growth models. It is also suggested to evaluate PIT tags as an alternative to Monel bird bands currently used to reduce the amount of tag loss.
2. Due to the lack of small fish collected in tributaries, an investigation into tributary and UMR dynamics and use of Shovelnose Sturgeon throughout multiple life stages (e.g., larval, immature, and mature adults) is suggested (e.g., telemetry, microchemistry, and/or sampling and tagging fish in new locations).
3. Further monitoring and evaluation of the regulation change on the UMR is suggested to determine long term effectiveness.
4. It is also suggested to continue to work with interconnected state agencies (e.g., Illinois) to continue to develop consistent regulations and management strategies.

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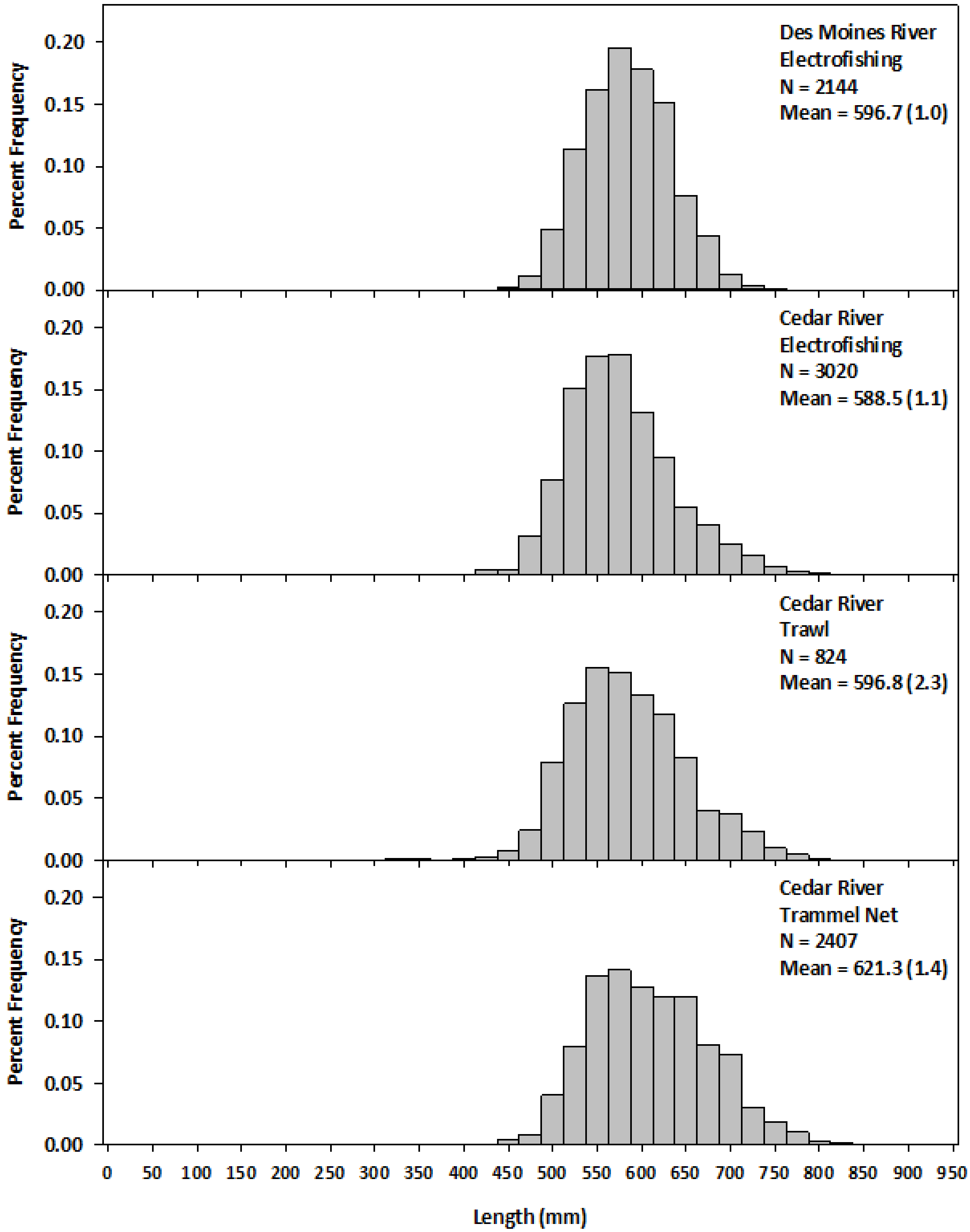

Figure 5. Length frequency distributions with mean length (SE) of Shovelnose Sturgeon collected via electrofishing, trammel netting and trawling in the Cedar River and via electrofishing in the Des Moines River from 2015-2018.

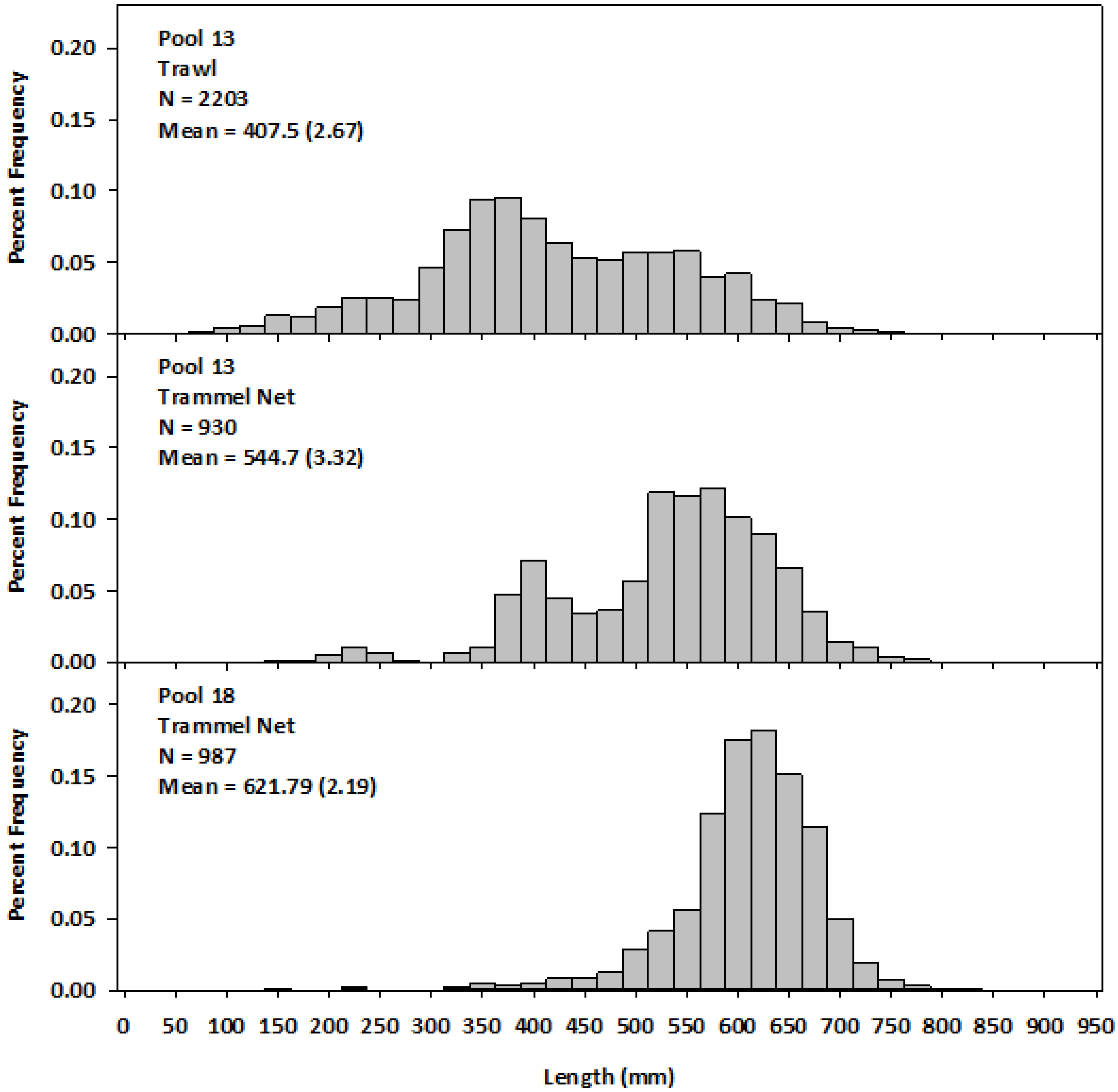

Figure 6. Length frequency distributions with mean length (SE) of Shovelnose Sturgeon collected via trawling in Pool 13 (years: 1993-2019), trammel netting in Pool 13 (years: 2015 and 2017) and Pool 18 (years: 2015, 2017, and 2018) of the Upper Mississippi River.

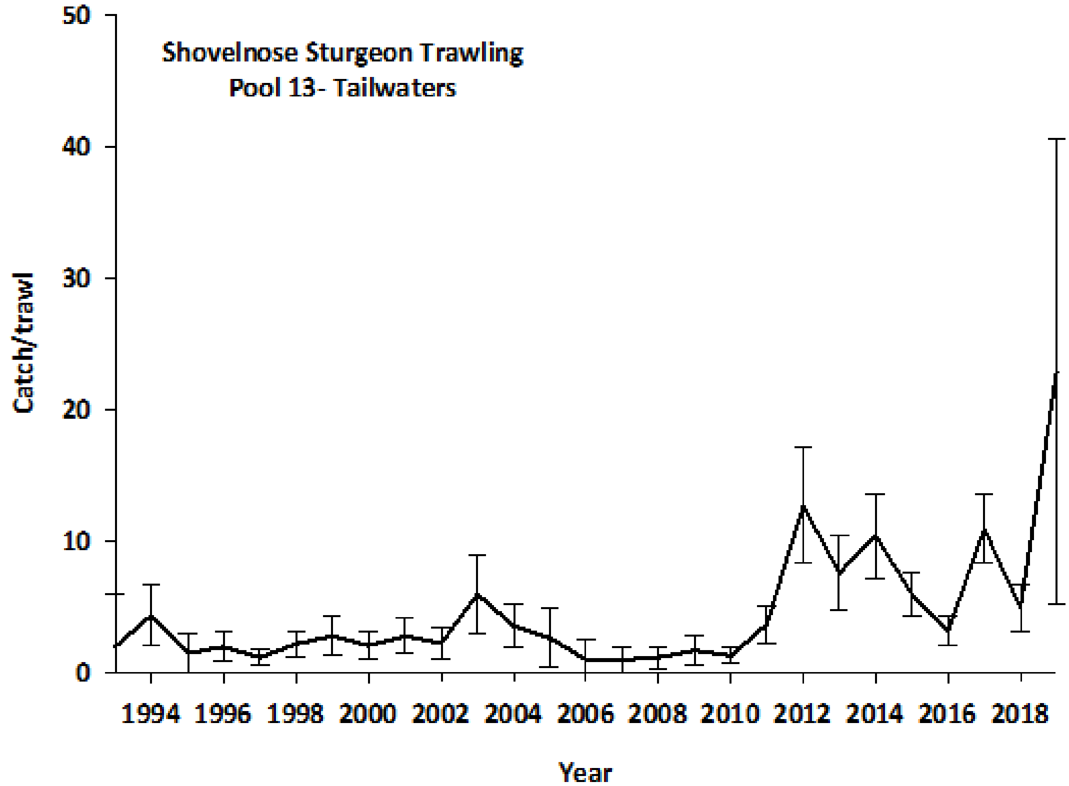

Figure 7. Trends in mean catch per unit effort (CPUE) of Shovelnose Sturgeon in Pool 13 tailwater trawling used in Long Term Resource Monitoring Element sampling from 1993-2019.

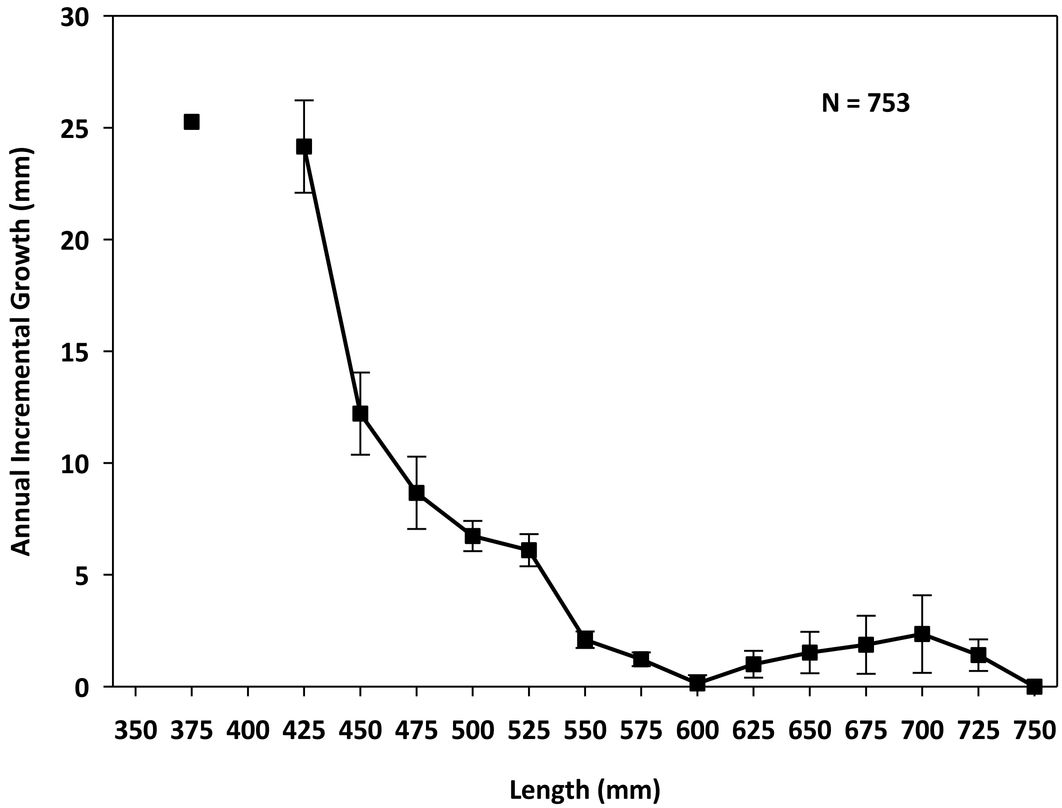

Figure 8. Annual increment of growth for Shovelnose Sturgeon from the Cedar River derived from mark-recapture data from initial length at capture to subsequent growth that occurred thereafter.

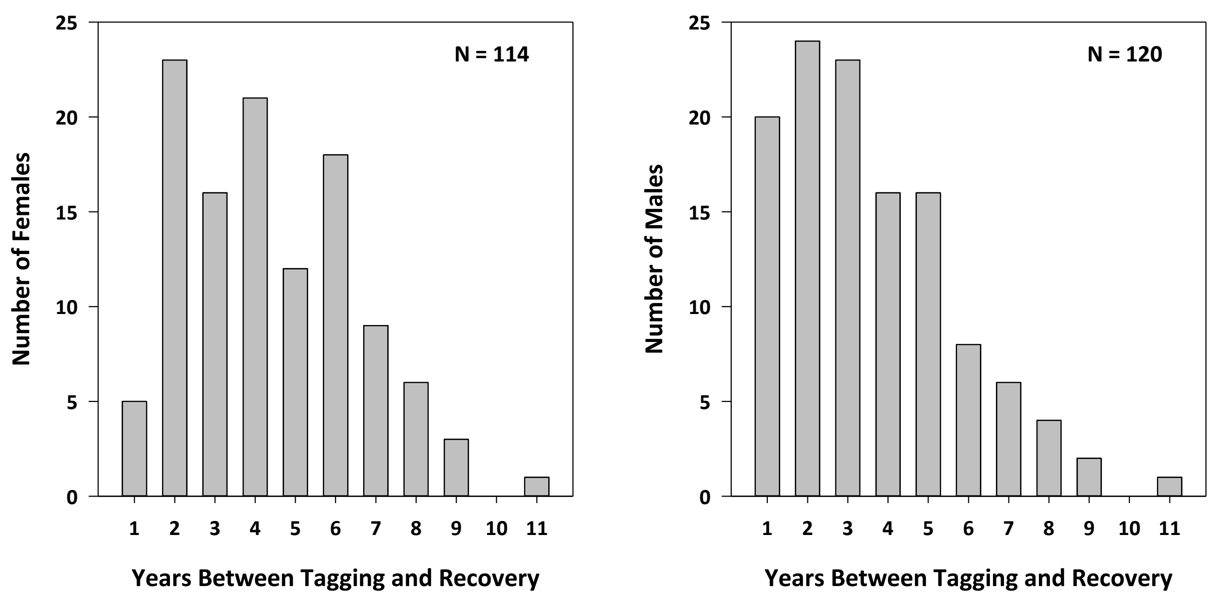

Figure 9. Frequency distribution of years between tagging and recovery of gravid female (left panel) and male (right panel) Shovelnose Sturgeon tagged and recaptured on the Cedar River, Iowa from 2006-2018.

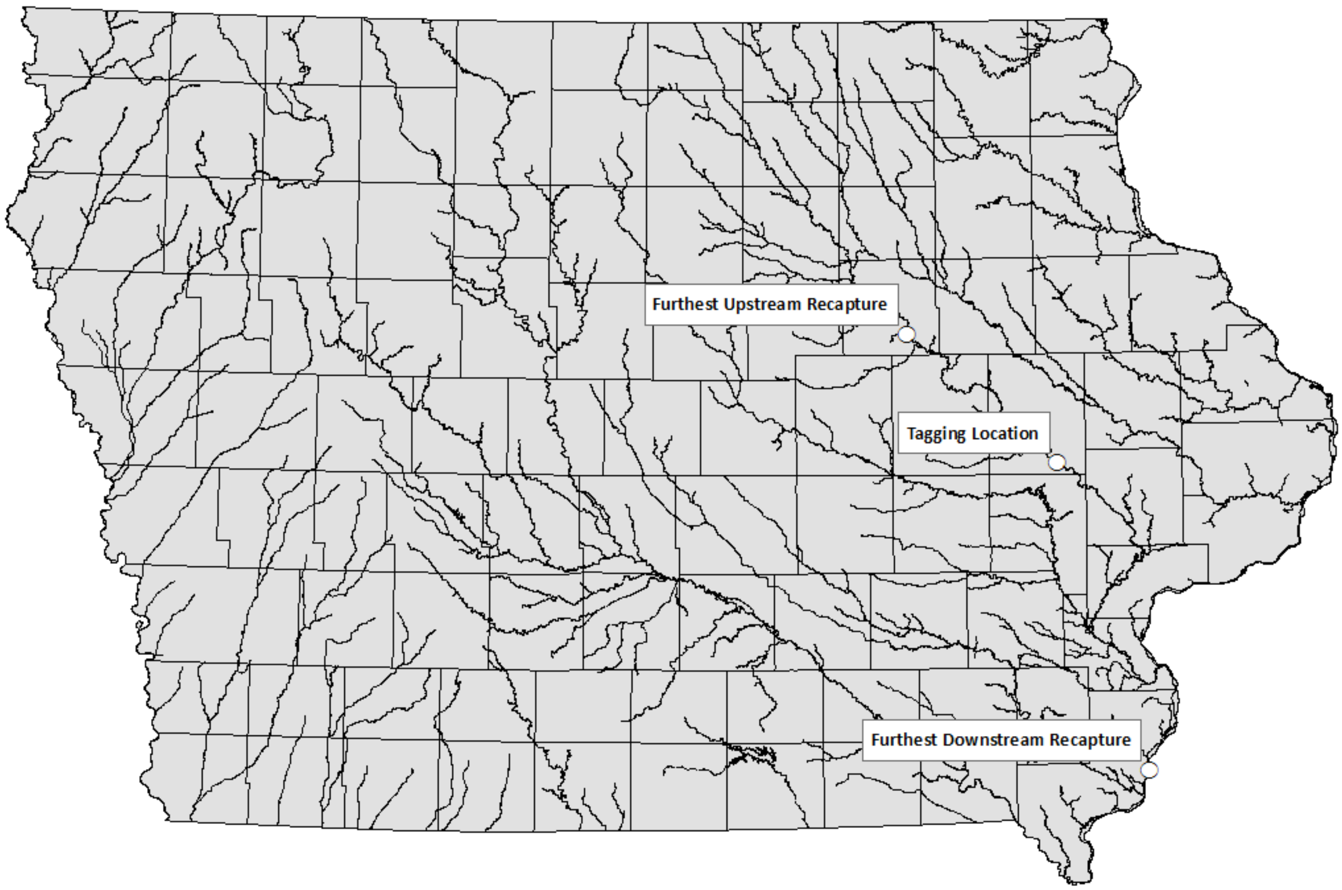

Figure 10. Primary sampling location (Tagging Location) on the Cedar River and furthest upstream and downstream movement of recaptured Shovelnose Sturgeon tagged in the Cedar River.