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Red River of the North

Channel Catfish Population Assessment

Summer 2022

River Mile 0.0 to 400.4

Minnesota Department of Natural Resources
Division of Fish and Wildlife

By

Nicholas Kludt

Submitted by: Nicholas Kludt Digitally signed by Nicholas Kludt Date: 2023.04.28 08:05:26 -05'00'

Approved by: Matt Skoog, Baudette Area Fisheries Supervisor
Nathan Olson, Detroit Lakes Area Fisheries Supervisor
Jim Wolters, Fergus Falls Area Fisheries Supervisor

Approved by: Ted Sledge Digitally signed by Ted Sledge Date: 2023.05.03 14:47:36 -05'00'
Regional Fisheries Manager

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Abstract

Four Channel Catfish population monitoring sites located on Red River of the North were sampled in late spring and summer of 2022. Reach 1, Site 1 and Reach 2, Site 1 were sampled using trap nets and Reach 3, Site 1 and Reach 4, Site 3 were sampled using a combination of trap nets and trotlines.

Channel Catfish trap net catches were double to triple those recorded in prior surveys. Trap net catch rates were 153.3/net in Reach 1; 102.4/net in Reach 2; 8.3/net in Reach 3, and 6.1/net in Reach 4. In Reaches 1 through 3, Channel Catfish were the most numerous species sampled. In Reach 4, Freshwater Drum and Quillback were more abundant.

Mean lengths of Channel Catfish were indicative of large 2019 and 2020 year classes. Mean length was 13.0 inches in Reach 1; 11.1 inches in Reach 2; 12.4 inches in Reach 3; 10.5 inches in Reach 4. Field conditions reduced catches of large (≥ 24 inch) individuals, as flow and temperature in the Reach 2 and 3 survey periods triggered the onset of spawning, after a delayed spring warmup. A large thunderstorm subsequently altered conditions, and auxiliary reporting from a large fishing tournament revealed a record high catch of large individuals.

Channel Catfish recruitment remains remarkably consistent. Catch curve residuals demonstrated the oscillatory pattern typical of Ricker-type recruitment. Year class production continued to follow a 4 to 6 year wavelength between strong year classes, and the same was observed for weak year classes. Note that these are relative descriptions, and year class production has remained steady and likely will continue to do so.

Growth rates for ages 3-15 continued to exhibit hyperstablity, and are not responsive to widespread habitat and hydrologic changes to the system since 1995. A Gompertz model showed consistency between the 2022 survey and the 1995-2015 results. This is comparable to the 50th-percentile growth rate for Channel Catfish in North America, despite the shorter growing season at the Red River's northerly latitude.

Overall, the quality of the Red River Channel Catfish fishery appears to be unchanged. Secondary fisheries (Sauger, Walleye) also appear to be healthy and continue to support seasonal use from local anglers.

Introduction

Beginning in the 1980's, the Red River of the North (here in: Red River) gained notoriety as one of the premier Channel Catfish fisheries in North America. At the time, little information was available describing the Red River fish populations.

In 1988, in response to an increasing awareness of the fishery and concerns of overexploitation of large Channel Catfish, a working group (now called the Red River Fisheries Steering Committee, or RRFSC) was formed between the Minnesota Department of Natural Resources (MNDNR), the North Dakota Game and Fish Department (NDGFD), the South Dakota Game, Fish and Parks (SDGFP), and the Manitoba Ministry of Natural Resources. The RRFSC has since worked to coordinate management efforts, standardize survey techniques, and standardize regulations in order to protect the Red River's trophy Channel Catfish population.

In 1990, Minnesota and North Dakota adopted similar Channel Catfish regulations for the Red River and its tributaries, specifying a five fish bag limit with only one exceeding 24 inches in length. This aligned with Manitoba regulations aimed at protecting the Red River size structure. In 2000, Minnesota and North Dakota standardized their fishing regulations on the Red River for all species. The fishing season was opened year round, with the exception of a conservation season that extended from March 1 through the first weekend of May. During the spring conservation season, bag limits for Walleye, Sauger and Northern Pike were reduced and size restrictions imposed. In 2004, the conservation season was eliminated, as well as the size restrictions on Walleye and Northern Pike.

Currently, the Red River fishing season is continuous on the Minnesota/North Dakota border waters. Regulations for the primary sport fish species are as follows: Channel Catfish, bag limit of five with only one fish over 24 inches; Walleye/Sauger (either or combined), a bag limit of three; Northern Pike, a bag limit of three; and Largemouth/Smallmouth Bass (aggregate), a bag limit of three. In 2015, Minnesota initiated a catch and release season for Lake Sturgeon, with a spawning season closure from April 15 through June 15.

Beginning in 1995, the MNDNR has conducted coordinated Red River fish population assessments every five years. The 2022 survey is part of the ongoing sampling effort, which was deferred 2 years due to the COVID-19 pandemic. MNDNR Fisheries personnel from the Baudette, Detroit Lakes and Fergus Falls Area Offices, with assistance from NDGFP staff, conducted the fisheries survey.

Specific objectives of this survey were to:

1) Collect information on fish species in Red River with primary emphasis on Channel Catfish

2) Monitor trends in Channel Catfish population abundance and size structure

3) Collect age and recruitment data for selected sport fish species

Study Area

The Red River begins at the confluence of the Bois de Sioux and Otter Tail rivers and flows northward approximately 545 miles through the bed of glacial Lake Agassiz where it empties into Lake Winnipeg (Figure 1, Table 1). The upstream 400 miles of the Red River forms the Minnesota-North Dakota border and the downstream 145 miles flow through southern Manitoba, Canada.

The Red River has a watershed area of approximately 45,000 square miles excluding the Assiniboine River basin, which joins the Red River at Winnipeg. Twenty-one primary sub-watersheds across Minnesota, North Dakota, and Manitoba empty into the Red River (Figure 1). Approximately 38.9% of the Red River watershed (17,500 mi^2) lies in Minnesota, 46.6% (21,000 mi^2) in North Dakota, 12.7% (5,700 mi^2) in Manitoba and 1.8% (810 mi^2) in South Dakota (Eddy et al. 1972). Land use throughout the basin is dominated by intensive agriculture.

In the Minnesota portion of the Red River watershed, the topography is very flat, with less than 2% slope over 58% of basin landscape area, and 80% less than a 6% slope (University of Minnesota, website). Red River Valley soils are silty-clay composition and poorly drained. Due to topography and soils, agricultural areas incorporate extensive ditch and tile drain systems designed to quickly remove excess surface water. The Red River Valley is prone to regular spring flooding, which is sometimes severe and can be exacerbated by these factors.

The Red River averages approximately 150 feet wide in the upstream reaches and approximately 250 feet wide in the lower reaches, ranging from 100 to 500 feet wide. Average thalweg depth ranges from 2.5 – 9.0 feet and a maximum of approximately 30 feet (Renard et al. 1986). The channel type varies from a C-6 in the upstream area near Brushvale, MN (Luther Aadland, pers. comm.); to a C/E near the Canadian border (Stewig, 2005a and 2005b). A more complete description of the Red River watershed is available in Topp et al (1994).

The Red River is a highly sinuous, low gradient river with an extensive floodplain. Stream sinuosity through the U.S. portion of the Red River averages 2.0, ranging from 1.6 to 2.6 through the different segments (Table 2). Stream gradient varies from 0.2 to 1.3 ft/mile (Renard et al. 1986). The highest gradient segment (1.3 ft/mi) is found between river mile (RM) 398 and RM380 just downstream from the former dam site at Wahpeton, ND/Breckenridge, MN (Figure 2). The next highest gradient segment (gradient = 0.9 ft/mi) is located from RM226 to RM181 between the confluences with Wild Rice River, Minnesota, and Sand Hill River, MN. As expected, the higher gradient segments contain the most riffles. Renard et al. (1986) reported the segment from RM226 to RM181 contained 15 individual riffles and the segment from RM398 to RM380 contained 4 riffles.

Eight low head dams were built on the mainstem of Red River in the U.S. reach. These have reduced the gradient of upstream segments compared to the natural channel profile. For instance, the construction of the Midtown and North dams in Fargo, ND, reduced the stream gradient through that stretch of river from its original 1.8 ft/mile to the present 0.2 ft/mile. Although these have been modified for fish passage, the upstream pools and attendant gradient reductions remain, as the dam crests are maintained.

Historically, the eight low head mainstem dams negatively impacted fish passage. As part of restoration efforts to “Reconnect the Red,” seven of the eight dams have been converted into rock-arch rapids to allow for fish passage, remove erosive hydraulic currents, and reduce public safety hazards (Table 3).

The final low head dam is located near the town of Drayton, ND. The Drayton Dam is being modified during the winter of 2022-23 as a mitigation requirement of the MNDNR’s “Plan B” project permit for the Fargo-Moorhead Area Diversion flood protection project. Drayton mitigation construction is expected to be completed by fall of 2023. As part of the flood protection scheme, the Diversion will construct a water control structure on the mainstem Red River south of Fargo-Moorhead. The structure will incorporate three tainter gates, which will remain out of the water and allow “run of the river” conditions when non-operational. The structure and attendant infrastructure will begin operating at the 20-year flood stage height, or the 5% annual exceedance probability event. During operations, it will be a fish passage barrier. An additional dam lies on the Canadian segment of mainstem Red River at Lockport, Manitoba, and is passable during high flows.

Annual precipitation in the Minnesota portion of the watershed ranges from 18 inches in the northwest to 27 inches in the southeast (University of Minnesota, website). Mean annual flow for the Red River at Wahpeton, ND is 657 cubic feet per second (cfs) and increases to 4,514 cfs at Drayton, ND, and is approximately 8,400 cfs at Lake Winnipeg (Aadland et al. 2005). The majority of the Red River's annual flow comes from the eastern (Minnesota) tributaries as a result of regional precipitation patterns, evapotranspiration, soil types, and topography (Stoner et al. 1993). Most runoff occurs in spring and early summer as a result of rains falling on melting snow or heavy rains falling on saturated soils.

The Red River is a warmwater stream with temperatures that regularly reach into the low 80s°F in July and August, and ices over in the winter. Red River is known for its high concentration of suspended solids, which results primarily from fine clay and silt sediments from the glacial lake plain. Median concentrations of total suspended solids during open water periods are noticeably higher downstream from the tributary confluences of Sheyenne River (ND), Buffalo River (MN) and Wild Rice River (MN) compared to upstream (Paakh et al. 2006). Suspended sediment contributions from tributary streams are likely a factor. The two Minnesota tributary streams that drain into Red River upstream from these confluences, Bois de Sioux River and Otter Tail River, have lower median suspended sediment concentrations that any of the other Minnesota tributary streams in the Red River Valley (Paakh et al. 2006). North Dakota and Minnesota list the Red River, along with many of the tributary streams, as impaired waters due to turbidity (MPCA 2010). Primary sources include stream channel erosion, agricultural runoff resulting from changes in vegetative land cover types, and hydrologic alterations to the watershed.

Dissolved oxygen (DO) levels in the Red River mainstem generally stay above 5 mg/l. However, occasional dips in DO are known to have occurred. The Minnesota Pollution Control Agency (MPCA) reported Red River DO levels in Fargo reached a low of 0.40 mg/l in August 2003 and the USGS gage station in Fargo documented DO levels below 4.0 mg/l on July 25 and 26, 2006 (MPCA 2007, unpublished). Each of these events coincided with a documented fish kill in the area. Many tributary stream segments are listed as impaired due to low dissolved oxygen levels (MPCA 2010).

For management purposes, the Red River is divided into four reaches (Figure 3). Management is shared between MNDNR and NDGFD, with MNDNR providing most of the river survey capacity. Reaches are numbered sequentially from 1 to 4 with the upstream boundary of Reach 1 located at the beginning of the named Red River of the North (Figure 3) and the downstream boundary of Reach 4 located at the Canada border. River mile (RM) labelling is inverse to the usual convention of beginning at the start of the river. Instead, RM 0.0 begins at the Canada border and ends at RM 400.4, the geographic start of the named Red River, which is the upstream boundary of Reach 1.

The Red River spans multiple Fisheries Areas in Minnesota, thus coordination is conducted at the Regional level. Reach 1 is surveyed by the Fergus Falls Area, and extends from the confluence of the Bois de Sioux and Ottertail rivers (RM 400.4) in Wahpeton-Breckenridge north to the Fargo North dam (RM 307.5). Reach 2 is surveyed by the Detroit Lakes Area, and extends from the Fargo North dam (RM 307.5) to the Riverside dam in Grand Forks (RM 144.6).

Reach 3 is surveyed by the Baudette Area and extends from Riverside dam (RM 144.6) north to the Drayton dam (RM 49.5) in Drayton, ND. Reach 4 is surveyed by the Baudette Area and extends from the Drayton dam (RM 49.5) to the Canadian border with the province of Manitoba (RM 0.0). Survey and management coordination is conducted by the Red River Fisheries Specialist, a Regional staff member, in coordination with all affected Fisheries Area offices, depending on the issue.

Methods

The primary purpose of this survey was to provide information on Red River Channel Catfish sufficient to guide management decisions to achieve the population goals and objectives as outlined in the Red River of the North Fisheries Management Plan (MNDNR et al. 2008). The survey's focus was on Channel Catfish population size and age structure, as well as an index of abundance. Information was also reported regarding other fish species sampled. While survey timing ideally occurs in early June, high water levels necessitated sampling beginning June 13, and concluding July 14.

One Site is sampled within each management Reach (Figure 3), following previously established survey methods (Appendix 1). This nomenclature is somewhat misleading, as each Site is a survey reach of varying length (Table 4). Protocol directs the length of the Site is broken into equal distance subunits for each gear, with targeted placement of gear within the Site distance subunits. The goal is maximized Channel Catfish catches per subunit, while recognizing some subunits will fish better than others.

While the targeted gear placement is a reasonable accommodation for dynamic river conditions, differing Site reach lengths is potentially problematic. Ricker (1975) referred to this potential problem as "competition by units of gear," whereby individual nets interfere or influence catches of adjacent nets. Simply, there is a potential lack of independence among samples, which is a foundational assumption of many common experimental designs and statistical methods. There is also the potential for inflated catches in some reaches, as the longer Site length allows for greater flexibility in targeted gear placement. Potential consequences of this spatial design are explored in Appendix II.

In a recurring issue, the survey methods (Appendix I) stated Reach 4, Site 2 would be used as the northern-most monitoring site. This site is a primitive access 10 miles west of Hallock and adjacent to the MN Hwy.175 bridge. It is sometimes referred to as the Golden Grains Bridge Access, and does not have a boat ramp. This site could not be sampled in 2022, 2015, or 2010 due to high water and impossible access conditions. Prior Red River reports list Reach 4, Site 3 as an alternative site. This site, originally described as "Pembina, ND" and shown near Pembina on old and oft-reused maps, has two separate sets of coordinates in the DNR's records. One set of coordinates is near Pembina, 21 miles northwest of Hallock, MN. The other is near the Hilltop boat access, approximately 15 miles west of Hallock, MN. The Hilltop access is maintained by DNR Parks and Trails and is located closer to in-state lodging options. This eliminates the need for out-of-state travel coordination and reduces daily travel distances. The Reach 4, Site 3 coordinates in the DNR Fisheries Survey Module are associated with the Hilltop

Access location, so these locations were used. Maps herein are updated to reflect this choice, and future usage is noted in the Management Recommendations section.

Crews set 30 trap nets at all Reaches and set 18 trotlines at Reach 3 and 4. Trap net and trotline sets were systematically distributed throughout Site distance subunits and fished for one night. All captured fish were identified and counted. Individual Channel Catfish were measured (total length), along with other game fish and Freshwater Drum. The latter was part of a research collaboration with University of Nebraska-Lincoln. An issue arose early in the survey regarding subsampling for fish length measurement. The methods issue, consequences, and proposed resolution is described in Appendix III. Aging structures were taken from Channel Catfish, Walleye, Sauger, and Freshwater Drum.

Fish age sample collection followed the Lake Survey Manual, following a length-stratified systematic approach. Attempts were made to sample 5 fish per 10 mm bin for fish <300 mm, and transitioned to 25 fish per 25mm length bin for fish >300 mm, using disarticulated pectoral spines. Due to hyperstability of Red River Channel Catfish growth rates from 1990 – 2015 and among sample reaches throughout that time, age structure collection was not reach-specific.

Age subsampling ceased at ~30 inches, or 750 mm; no fish >750 mm were sampled for aging. These large fish have generally exceeded an asymptotic growth threshold, and trophy fish aging, although interesting, does not have immediate utility. Monitoring growth rate to trophy size is the primary management concern. Literature on spine disarticulation survival rate is not widely available for large Channel Catfish, as most experimental samples are dominated by individuals < 700 mm (e.g. Michaletz 2005). Additionally, while disarticulated Channel Catfish in smaller size classes are caught and reported by Red River guides following the Red River survey, disarticulated memorable or trophy size individuals are not anecdotally reported. DNR staff have noted and expressed concern about the proportionally larger wound size created by disarticulating spines from trophy-size individuals. Finally, DNR staff who routinely age Channel Catfish note poor quality of age estimates for large individuals, due to degradation of the annuli near the center of the spine. For Red River specimens, extensive or large vaterite inclusions are relatively common in large fish, leading to unreadable sections. The data quality and use concerns, and to a lesser extent the mortality and fish health concerns, were the factors that contributed to this decision.

Channel Catfish spines were cleaned, dried, and cross sectioned using an IsoMet low speed saw with a Buehler 15LC diamond blade; this particular blade yielded very clear annuli with no or minimal additional polishing required. Cross sections were taken from the articulating process, following suggestions from Tony Sindt, MNDNR Minnesota River specialist. Sectioning information is available from the MNDNR Catfish Technical Committee. Cross sections were aged, and mean length at age determined. A Gompertz (1825) growth curve was applied to the mean length at age data, using least-squares model fitting. An age-length key (ALK) was used to assign age estimates to Channel Catfish that were measured independent of the aging subsample (Isely and Grabowski 2007). These were pooled with the aging sample irrespective of reach, on the assumption of no stock discrimination within the fishery. A log-transformed catch curve (Ricker 1975) was created for the pooled aging and age-assigned Channel Catfish data. The slope of the linearized catch-curve regression was then converted to an estimated annual mortality rate (Ricker 1975), and the residuals were examined for year class production patterns (Maceina 1997).

Catch per unit effort (CPUE) was calculated separately for trap nets and trotlines. Length-frequency distributions were constructed separately for trap nets and trot lines. The following size distribution indices for Channel Catfish were calculated using trap net data from all Reaches: percent size distribution (PSD), percent size distribution of fish ≥20 inches (PSD_{20}), percent size distribution of fish ≥ 24 inches (PSD_{24}) and percent size distribution of fish ≥ 30 inches (PSD_{30}) using the standard Channel Catfish stock size of 11 inches and a quality size of 16 inches. This was replicated using trotline data in Reaches 3 and 4.

Prior surveys sought to fill targeted sampling quotas of Channel Catfish ≥20 inches, as there was interest in the age distribution of larger individuals. These data required extra gear sets and data were segregated from the primary catches and derived analyses and indices. Targeted collections were only used to examine maximum ages. As present Red River management objectives are based on size and catch rate targets, this component was discontinued in 2022.

Prior evaluation of survey data showed trap nets to be selective for capturing Channel Catfish ≥ 10 inches and trot lines to be selective for catfish ≥20 inches. In some years, trap net and trotline catches were pooled for analysis due to low catches of both gears; however, this impairs inter-Reach comparisons, due to the previously acknowledged gear selectivity and subsequent biases induced by pooling catch data. The 2022 catch totals were sufficient to keep the gear-specific sampling data separate in Reaches 3 and 4, where both gears were fished.

Efforts were made to fish the standard number of gears in all reaches (Table 4). This was foiled occasionally by fouled nets and trotlines. In the case of fouled nets, the denominator for CPUE calculations was simply adjusted. In the case of snagged and partially recovered trotlines, the CPUE was scaled to the number of hooks recovered in a given reach.

Results

The Red River and its tributaries are inhabited by 87 fish species representing 20 families (Aadland et al. 2005). Of these, 37 species have been detected in the mainstem during Channel Catfish sampling efforts since 1995 (Table 5); these are primarily larger-bodied species vulnerable to detection as bycatch in trap nets. Presence and absence of smaller bodied species, which have a lower assumed trap net detection probability, is obtained through data sharing with MPCA.

The 2022 spring was cold and delayed, and there was concern the Red River survey would be delayed another year due to high flows that persisted through May and into early June. Reach 1 was sampled June 13-16. Reaches 2 and 3 were sampled June 20-23. Reach 4, lower in the watershed, remained inaccessible with breakout flows into the floodplain until July 11-14, when crews were able to set gear.

Red River discharge was declining at the time each site was sampled (Figures 4, 5, 6 and 7). Reach 4, Site 3 does not have a gauge in close proximity, so the upstream Drayton Dam gauge was used. At 36 miles upstream of Reach 4, this is the closest mainstem gauge available. Water temperature was above 75°F and approaching 80°F when Reaches 2 and 3 were sampled, although large rain events subsequently depressed temperatures (Figures 5, 6).

For consistency with prior reports and based on methods employed herein, it was convenient to divide results into reach-specific and non-specific, whole-river results.

Reach 1, Site 1

A total of 4,992 fish representing 21 species were captured at this site during standardized trap net sampling in 2022 (Table 6). Channel Catfish was the most abundant species (153.3 fish/net) captured followed by Goldeye (11.7 fish/net; Table 6). Channel Catfish comprised 89% of the individuals sampled at this site. Crews had 1 trap net collapse due to current.

Channel Catfish

A total of 4,445 Channel Catfish (CPUE = 153.3 fish/net) were sampled in the 29 standard trap net sets in Reach 1 (Table 6). Catfish lengths ranged from 7-37 inches (mean length = 13.0 inches), with a mode of 10 inches (Table 7, Figure 8).

There were 1,380 Channel Catfish of stock size (11 inches) or greater and 465 catfish of quality size (16 inches or greater) were captured in Reach 1, resulting in a PSD of 34 (Table 10). Other size distribution index values were: PSD_{20} = 12, PSD_{24} = 5 and PSD_{30}= 1.

Sauger

No Sauger were sampled at Reach 1.

Walleye

A total of 10 Walleye ranging from 14 to 29 inches (mean length = 19.2 inches; Table 18) were sampled. The catch rate was 0.34 fish/net (Table 6).

Reach 2, Site 1

A total of 4,300 fish representing 23 species were captured at this site during standardized trap net sampling in 2022 (Table 6). Channel Catfish was the most abundant species (102.4 fish/net) captured followed by Quillback (15.9 fish/net; Table 6) and Black Bullhead (12.4 fish/net; Table 6). Channel Catfish comprised 67% of the individuals sampled at this site. Crews had 2 trap nets collapse due to current.

Channel Catfish

In the 28 standard trap nets, 2,866 (102.4 fish/net) Channel Catfish were captured in Reach 2. Channel Catfish ranged from 5-31 inches, with a mean length of 11.1 inches and a mode of 9 inches (Table 7, Figure 9).

There were 838 Channel Catfish of stock size (11 inches) or greater and 171 catfish of quality size (16 inches or greater) were captured in Reach 1, resulting in a PSD of 20 (Table 11). Other size distribution index values were: PSD_{20} = 5, PSD_{24} = 2 and PSD_{30}= 0.

Sauger

A total of 19 Sauger were sampled ranging from 11 to 17 inches (mean length = 14.2 inches; Table 17). Most (84%) were 12-16 inches. The catch rate was 0.68 fish/net (Table 6).

Walleye

A total of 25 Walleye were sampled ranging from 12 to 21 inches (mean length = 14.6 inches; Table 18). Distribution was bimodal at 13 and 16 inches. The catch rate was 0.93 fish/net (Table 6).

Reach 3, Site 1

A total of 802 fish representing 18 species were captured at this site during standardized trap net sampling in 2022 (Table 6). Channel Catfish was the most abundant species (8.3 fish/net) captured followed by Freshwater Drum (5.5 fish/net; Table 6) and Goldeye (2.9 fish/net; Table 6). Channel Catfish comprised 31% of the individuals sampled at this site.

Channel Catfish

A total of 249 Channel Catfish (CPUE = 8.3 fish/net) were sampled in the 30 standard trap net sets in Reach 3. Catfish lengths captured in trap nets ranged from <5-40 inches (mean length = 12.4 inches), with a mode of 9 inches (Table 7, Figure 10).

The standard 18 trotline-sets, corrected for breakage, sampled 46 Channel Catfish in Reach 3 (CPUE = 2.9, Table 12). Of these, 45.7% were ≥ 20 inches, 17.4% ≥ 24 inches, and 8.7% ≥ 30 inches (Table 8). The catch rate of Channel Catfish ≥ 24 inches was 0.5 fish/line-set. Catfish ranged from 15 to 33 inches; the average length was 21.1 inches.

Sauger

A total of 73 Sauger were sampled ranging from 9 to 17 inches (mean length = 12.6 inches; Table 17). Most (84%) were 11-15 inches. The catch rate was 0.63 fish/net (Table 6).

Walleye

A total of 32 Walleye were sampled ranging from 11 to 18 inches (mean length = 14.0 inches; Table 18). Most (90%) were 12-16 inches. The catch rate was 1.07 fish/net (Table 6).

Reach 4, Site 3

A total of 1203 fish representing 17 species were captured at this site during standardized trap net sampling in 2022 (Table 6). Freshwater Drum was the most abundant species (10.8 fish/net) captured followed by Quillback (7.9 fish/net; Table 6) and Goldeye (6.8 fish/net; Table 6). Channel Catfish catches were 6.1 fish/net, and comprised 15% of the individuals sampled at this site.

<u>Channel Catfish</u>

A total of 184 Channel Catfish (CPUE = 6.1 fish/net) were sampled in the 30 standard trap net sets in Reach 4 (Table 6). Catfish lengths captured in trap nets ranged from <5-33 inches (mean length = 10.5 inches), with a mode of 9 inches (Table 7, Figure 11).

The standard 18 trotline-sets sampled 75 Channel Catfish in Reach 4 (CPUE = 4.2, Table 12). Of these, 74.7% were ≥ 20 inches, 49.3% ≥ 24 inches, and 17.3% ≥ 30 inches (Table 8). The catch rate of Channel Catfish ≥ 24 inches was 2.1 fish/line-set. Catfish ranged from 14 to 36 inches; the average length was 24.2 inches.

<u>Sauger</u>

A total of 27 Sauger were sampled ranging from 8 to 16 inches (mean length = 12.1 inches; Table 17). Most (78%) were 11-15 inches. The catch rate was 0.90 fish/net (Table 6).

<u>Walleye</u>

A total of 8 Walleye were sampled ranging from 8 to 23 inches (mean length = 14.0 inches; Table 18). The catch rate was 0.27 fish/net (Table 6).

General

Channel Catfish age structure showed recruitment to the survey at approximately age-3 (Figure 12), after ALK assignment. The raw aging subsample showed similar trends (Figure 13), as logically expected. In either case, consistent year classes were visually evinced, with a right tailing age distribution reflective of consistent natural mortality. At no point in the size or aging distributions were there meaningful natural breaks, as are sometimes associated with the onset of heavy harvest pressure.

The Gompertz growth curve was selected over the more common von Bertalanffy model based on a visual assessment of model fit to the ALK-assigned mean length age data. The Gompertz model exhibited superior fit at 0 – 5 years, while both models performed well for the remainder of the data's right extent (Figure 14). This is likely due to calculation differences between the Gompertz N_0 and the von Bertalanffy L_0 parameters, both of which functionally describe the curve's x-intercept. This approximates fish length at formation of the first annulus, which is the length after a Channel Catfish's 1st overwintering. The Gompertz model estimated this value at a realistic 6.3 inches, as opposed to the von Bertalanffy's 3.2 inches.

The 2022 growth rate was consistent at ages 3-15, when compared to prior Red River surveys (Figure 15). Divergence of growth curves at ages greater than 15 years was noted, as compared to a Gompertz curve fitted to the 1995-2015 survey's grand mean of length at age (Figure 15). The 2022 curve deflected downward at ages 15 and greater, as a modelling artifact of the 750mm threshold; only older, relatively shorted individuals and resultant estimates underlay this portion of the regression. Conversely, prior surveys leveraged the growth curve upward in the extreme data extent due to intentional targeting of larger individuals. While primarily a statistical artifact, these detections demonstrate the persistence of older individuals present in the Red River Channel Catfish population, as previously shown (Figure 14).

The 2022 growth rate continues to compare favorably to external Red River research (Figure 16). Compared to a meta-analysis of growth rate, the Red River growth rate is approximately equivalent to the 50^{th}-percentile of North American populations (Figure 16).

Annual mortality rates for Channel Catfish were calculated using Channel Catfish ages 3-19, which reflects full recruitment to gear and retains enough older individuals for reasonable model fitting. The 2022 annual mortality estimate was 0.32 (Figure 17), which was higher than the 2015 estimate of 0.25 (Wendel 2016). Estimates were also calculated on a subset of Channel Catfish ages 3 – 10, which limits estimates to immature Red River Channel Catfish. The 2022 juvenile annual mortality estimate was 0.34, and the recalculated 2015 estimate was 0.23. This demonstrates the leveraging influence of the vastly greater 2022 CPUE of juvenile and young (age 3 and 4) catfish (Figure 12), relative to prior surveys (Table 9). This abundance creates a higher initial inflection point for the overall catch curve slope, thus the annual mortality estimates.

Recruitment trends for Channel Catfish in the Red River remain steady, based on the catch curve residuals (Figure 18). An estimated 72.7% of Channel Catfish were under 5 years old. Catch curve residuals exhibited the oscillatory pattern characteristic of classical Ricker (1975) stock-recruitment relationships; implications thereof are discussed later. While correlation of the 2015 and 2022 overlapping catch curve residuals (2003 – 2012) was not significant ($r = 0.31$, p = 0.37), general pattern was comparable (Figure 18).

Sauger age structure was well distributed, with all age classes up to age-13 represented in the sample (Figure 19). Catch-curve residuals indicate consistent recruitment for the past decade (Figure 20), which produced the observed balanced age structure. Catch-curve residuals were comparable where overlap existed between the 2022 and 2015 results. As noted in the 2010 and 2015 surveys, the 2006 year class was particularly strong, and was followed by two poor year classes. No year classes of similar magnitude have been produced, and recruitment has been more consistent in recent years. Individuals from the 2016 – 2018 year classes made up 47% of the sample (Table 17). Sauger growth was strongly asymptotic nearing 14 inches, and the largest individual sampled was 16.5 inches. Annual mortality rate for the 2022 sample was estimated at 20%, which is comparable to the 26% estimated in 2015.

Walleye age structure was dominated by younger fish, with an age structure generally ranging from 1 to 9 years of age. Individuals from the 2017 – 2020 year classes made up 65% of the sample (Table 18). Several older individuals were also detected, with a maximum age of 15 years (Figure 21). Catch-curve residuals indicate generally consistent recruitment, with occasional weak year classes such as 2016 (Figure 22). Catch-curve residuals were very comparable where overlap existed between the 2022 and 2015 results. Walleye growth was asymptotic nearing 15 inches, but high variance of length-at-age made growth model fit generally poor. The largest individual sampled was 25.1 inches, although anglers report catches of larger individuals. Annual mortality rate for the 2022 sample was estimated at 26%, similar to the 24% estimated in 2015.

Discussion

This section is again divided into reach-specific discussions, and a general discussion section. The reach-specific sections focus on performance relative to established management objectives.

Reach 1, Site 1

Management objectives for Reach 1 are trap net CPUE = 57 fish/lift and PSD24 = 2.

The Channel Catfish trap net catch rate in Reach 1 increased from 40.3 fish/net in 2015 to 153.28 fish/net in 2022. This was the highest CPUE recorded since the survey began in 1995 (Table 9). The 2022 catch rate was well above the objective established for this reach.

The Channel Catfish trap net PSD value from this site was 34 in 2022, up from 26 in 2015. That survey had the lowest value of any survey in Reach 1 since 1995. The current PSD aligned with those of prior surveys in 2010 and 2005 (Table 10). The PSD24 value was 5, and exceeded the management goal.

The Red River management plan calls for a PSD goal of 50 in Reach 1, yet this may be difficult to achieve as younger age classes remain common in this reach (Figure 8). In 2015, 51% of Channel Catfish (n = 591) were between 11.0 and 12.9 inches. In 2022, 51% of Channel Catfish (n = 1373) were between 9.0 and 11.9 inches. High catch rates of younger, smaller fish are likely to continue depressing PSD values in Reach 1. If higher PSD values are observed in the future, especially if the change is substantial enough that PSD nears the management plan goal, particular care should be given to evaluation of year class strength or failure. It is unlikely Channel Catfish PSD in this reach will be 50, except through a major population shift or disturbance.

Based on a visual assessment, this reach has the highest percent area of woody cover in the channel, compared to other survey reaches. This may contribute to the consistently-observed year class production at the site. Attention should be given to preserving this habitat resource.

Reach 2, Site 1

Management objectives for Reach 2 are trap net CPUE = 18 fish/lift and PSD24 = 9.

The Channel Catfish trap net catch rate in Reach 2 increased from 12.9 fish/net in 2015 to 95.5 fish/net in 2022. This was the highest CPUE recorded since the survey began in 1995 (Table 9). The 2022 catch rate was well above the objective established for this reach.

The Channel Catfish PSD value from this site was 20 in 2022, down from the 42 in 2015. That is the lowest value of any survey in Reach 2 (Table 11). The current PSD value is likely driven by a high sampled abundance of younger, smaller fish (Table 7). This low value does not fully reflect the high abundance of small fish at this site. Nearly 50% of Channel Catfish sampled at this site were between 7.0 and 11.9 inches (n = 1638). Stock size for Channel Catfish is ≥11 inches; thus, only a subset (n = 232) of these young fish were included in the PSD calculation.

This survey's trap net PSD24 value was 2, which is under the management goal. While size indices can be skewed by factors including as those previously discussed, the raw number of Channel Catfish ≥ 24 inches sampled in 2022 was 14 (n_{total} = 2266), compared to 41 (n_{total} = 714) in 2015.

Generally, fewer large individuals were sampled in 2022, despite higher catches overall.

Reach 3, Site 1

Management objectives for Reach 3 are trap net CPUE = 1.5 fish/lift. Additionally, trotline objectives are 4.5 fish/set, with 1.6 fish ≥ 24 inches.

The Channel Catfish trap net catch rate in Reach 3 increased from 2.0 fish/net in 2015 to 8.3 fish/net in 2022. This was the highest CPUE recorded since the survey began in 1995 (Table 9). The 2022 catch rate was above the trap net objective established for this reach. The PSD value was 31, while PSD24 was 10; no management objectives exist for trap net catch size indices.

The trotline catch rate was 2.8 fish/lift, with 0.5 fish/lift ≥ 24 inches. These were below objectives and average, although the overall catch rate was comparable to a 3-survey running average (Table 12). The raw number of Channel Catfish ≥ 24 inches sampled in 2022 was 8 (n_{total} = 46), compared to 25 (n_{total} = 56) in 2015.

Although trap net catches were higher in 2022, combined gear detections of larger fish were lower.

Reach 4, Site 3

Management objectives for Reach 3 are trap net CPUE = 4 fish/lift. Additionally, trotline objectives are 4.0 fish/set, with 3.1 fish ≥ 24 inches.

The Channel Catfish trap net catch rate in Reach 4 increased from 2.2 fish/net in 2015 to 6.0 fish/net in 2022. This was the highest CPUE recorded since the survey began in 1995 (Table 9). The 2022 catch rate was above the trap net objective established for this reach. The PSD value was 37, while PSD24 was 26; no management objectives exist for trap net catch size indices.

The trotline catch rate was 4.2 fish/lift, with 2.1 fish/lift ≥ 24 inches. Catch rate met objectives, while abundance of larger sampled fish lagged slightly. Catches in both categories compared favorably to a 3-survey moving average. The raw number of Channel Catfish ≥ 24 inches sampled in 2022 was 37 (n_{total} = 75), compared to 46 (n_{total} = 99) in 2015.

Although trap net catches were higher in 2022, combined gear detections of larger fish were lower.

General

Channel Catfish catch rates were higher in 2022 than in all prior surveys, yet detections of individuals ≥ 24 inches were lower. Notably, sampling in Reaches 2, 3, and 4 occurred in late June after extended high water conditions throughout the spring. The Fargo and Grand Forks USGS gauges recorded water temperature ~ 78°F during sampling of these reaches. In Minnesota, Channel Catfish spawning typically begins at 75°F in June; cuing is a combination of temperature and photoperiod. As Channel Catfish are cavity nesters, movement declines sharply during the spawning period, thus reducing vulnerability to passive gears.

The Scheels Boundary Battle catfish tournament was held in Grand Forks one day after sampling in Reaches 2 and 3 concluded. During the intervening night, a major frontal system passed through the Red River region, producing severe thunderstorms and heavy rainfall throughout the valley. The storm's runoff dropped river temperature to 70 - 73°F, and caused a major flow bounce on the Fargo and Grand Forks gauges (see Figures 5,6). The decrease in temperature and increased flow seemed to interrupt spawning activity, and Channel Catfish reverted to a pre-spawn feeding pattern. This produced the heaviest winning and heaviest average of the "Top 10" tournament bag weights since 2016 (Table 15). The event is a two day tournament, typically held in late June, and is capped at 50 boats. Teams weigh in two catfish over 24" and one under 24" per day, with daily possession of three fish. Anecdotal angler reports of females expressing eggs for the next several weeks following this spawning interruption hinted at protracted spawning activity.

Sampling in Reach 4 yielded similar size structure results to previous surveys. In conjunction with the Reach 3 fishing tournament catches, we assume size structure has likely not declined in Reaches 2 and 3. Reproductive biology and resultant fish behavior were likely the causes of lower detections of fish ≥ 24 inches in those reaches.

Trap net catch rates of Channel Catfish were again highest in Reach 1, the most upstream portion of the Red River, similar to prior surveys. Catch rates declined in a downstream progression. The size structure and catch rate patterns continue to align with River Continuum Concept gradient predictions; however, catches also align with a longitudinal changes in cross-sectional slope of the river bed in the near-bank area. Upstream reaches had generally lower near-bank slope and were more conducive to level trap net frame placement. Downstream reaches had generally steeper near-bank slopes, and were less conducive to level gear placement. In the downstream reaches, some nets were statistical outliers and had high relative catches. These sites had a terraced bottom morphology, which allowed a net to sit level and create a current seam on the outside bend of the river. The near-shore slope influence is inescapable with trap nets, as the cod-end of the gear must be anchored to the shore. Thus, between-reach comparisons generally do not account for the reduced effectiveness of capturing Channel Catfish with trap nets in wider, deeper river segments found in Reaches 3 and 4.

Dynamic environmental conditions in this and prior Red River surveys always generate a level of uncertainty in estimates. Prior reports attribute catch rate variance to survey timing, discharge, temperature, and fish behavior. As the survey protocol encourages targeted gear placement to maximize catfish catch rates, crew skill and creativity are also a source of variance. All prior surveys caution comparing catch rate metrics to prior surveys; unfortunately, time series comparison is the primary reason for having long-term monitoring programs. It may be beneficial to explore an alternative gear comparison, with the intent of minimizing the confounding influences on trap nets previously highlighted.

Red River catfish management is primarily concerned with fish length, so maintaining size index objectives is logical. A single objective value, however, is not as useful as a range that allows for inter-survey variability. As multiple iterations of monitoring have been conducted on the Red River, the current size index targets can be revised into a range by the simple expedient of generating mean PSD24 values and associated 95% confidence intervals. The Reach 1 and 2 PSD24 goals are currently 2 and 9, respectively, so this revision provides both a target value and the expected range of observed values. Using the survey-standardization sampling era (2010 – present) and this approach, the Reach 1 PSD24 objective would be 3 ± 3, while Reach 2 PSD24 would be 7 ± 8. To avoid the inclusion of zero in the Reach 1 objective, this range requires an arbitrary truncation to 3 ± 2. Reaches 3 and 4 require sampling with comparable gears to establish similar, comparable objectives.

Observed Channel Catfish age distribution was uniform, with no indication of missing year classes. The Red River Channel Catfish population exhibits remarkably consistent year class production. Catch-curve residual oscillatory patterns, as shown in Figure 18, are indicative of a stable population that is exhibiting Ricker-type recruitment. The time interval between especially large year classes is equal to the wavelength, with the same time interval between weak year classes. The oscillations are on a 4 to 6 year wavelength, which was also observed in the 2015 residuals.

The 2015 survey noted underrepresentation of the 2007 – 2009 year classes. These correspond to the 13 – 15 year old fish in the 2022 aging data, and the residuals of both catch curves were compared (Figure 18). The weak year classes are no longer as strongly resolved in the 2022 data due to the dampening effects of mortality over time, but nevertheless correspond to the expected low point of the recruitment oscillatory pattern. Thus, the 2015 notation was not indicative of a problem, but was a detection of the recurring Channel Catfish recruitment pattern in this system. If present trends continue, the 2022 or 2023 year classes should be depressed relative to the strong 2019 year class.

The Channel Catfish recruitment pattern is a notable strength of the fishery. Prior reports and internal DNR discussions have considered recruitment objectives for the Red River, such as monitoring for consistent year class production. While it is difficult to manage for Channel Catfish recruitment, maintaining the highly desirable *status – quo* is in the fishery's best interest.

Growth rates remained steady for Channel Catfish. The 2015 and prior surveys were composited into a "grand mean" approximation of all previous surveys' mean length at age, and a Gompertz curve applied. The 2022 modelled growth rate for ages 3 – 10 remained comparable to previous Red River monitoring (Figure 15). This rates remains consistent with prior studies, and the range-wide 50% percentile growth rate (Figure 16). For management purposes, this is the most relevant data range, as it is the growth through these age classes that results in recruitment to the ≥ 24 inch size classes that are particularly important to the trophy Red River fishery.

Annual growth rate in the Red River (and at northern latitudes generally), despite being nominally slower than southern populations, is actually faster seasonally when standardized for temperature regime (Rypel 2011). While this may seem counterintuitive, this paradox likely arises because northern populations have a shorter growing season window (Rypel 2011). A similar pattern can be found in Lake Sturgeon *Acipenser fulvescens*, where size variation results from thermal opportunity for growth (Power and McKinley 1997). On a continental scale, this is referred to as a latitudinal countergradient in growth, and is quite common. Channel Catfish, Blue Catfish, Flathead Catfish, Brown Bullhead, and Black Bullhead all display latitudinal countergradients in growth (Rypel 2011). A number of other fishes have shown similar patterns, including Atlantic Silverside *Menidia menidia* (Conover and Present 1990), Striped Bass *Morone saxatilis* (Conover et al. 1997), and Mummichog *Fundulus heteroclitus* (Schultz et al. 1996). As a phenomenon conserved by all of the Ictalurids examined by Rypel (2011), the latitudinal countergradient in growth may have developed via evolutionary forces acting through natural selection, and therefore must have some genetic basis (Conover et al. 2005). This mechanism, however, remains unknown.

Annual mortality estimates again increased (Table 16); the 2015 survey also noted an increase in annual mortality rate, relative to Hegrenes (1992). Both of these occurred on the American reaches of the Red River. Lower mortality was reported in the Canadian reaches (Siddons 2015). The high proportion of large, adult fish in their sample may have leveraged mortality rate downward, relative to the 2015 American estimate. Inversely, the high mortality rate estimated in 2022 is likely due to extremely high catch rates of smaller, younger fish relative to other surveys, along with a combination of factors which reduced the sample size of larger-bodied adult fish. These two forces, acting in concert, effectively steepened the catch curve slope, thus increasing the mortality estimate. Nevertheless, mortality estimates seem to be trending upward, although this inference is weak due to the low number of estimates available (n = 6, Table 16).

If the Channel Catfish mortality rate continues to increase or remain elevated in future surveys, this may be evidence of shifting population dynamics. This is vitally important to monitor, as additive annual mortality has the ability to truncate the Red River age structure thus altering the size structure foundational to the Red River's trophy fishery status. If this trend continues, managers may face future regulation decisions regarding Channel Catfish size protections, as additive fishing mortality on the upper end of the size structure may need to be reduced.

Trotline data continue to be challenging. As a hook-and-line gear, trotlines are demonstrably sensitive to deployment skill and bait selection when targeting trophy Channel Catfish. Catch is sensitive to a wide array of environmental forces. Thus, it may be advisable to adopt a moving-average approach to comparisons with prior surveys, as this intentionally dampens the effects of crew and year. This is demonstrated in Table 12.

While useful as a targeted gear for detecting Channel Catfish presence, extreme caution should be exercised in using trotlines as a standard monitoring approach. They are highly vulnerable to depensatory monitoring effects, as the targeted gear placement by skillful crews could maintain catch rates of large individuals even if the population was undergoing a major size structure decline. Conversely, given the known sensitivities of the gear, it is entirely plausible that such a decline reflected in trotline catches would be dismissed as poor deployments. Given the 5-year survey interval, this error in inference would not be revealed for a minimum of 10 years unless poor catches triggered repeated sampling on a shorter interval.

A minimally-biased gear for detection of Channel Catfish relative abundance and size structure remains an elusive Red River survey goal. Efforts should focus on making this a reality for Reaches 3 and 4, addressing issues discussed for both trap nets and trotline gear deployments in these reaches.

Both Walleye and Sauger stocks in Lake Winnipeg remain depressed. Recent changes by the Manitoba Ministry to Natural Resources and Northern Development include moving to a 3.5 inch minimum bar mesh for commercial netting, with the goal of increasing spawning stock biomass in the fishery. Movement data from the Red River Acoustic Telemetry Array indicates Walleye below St. Andrews Dam generally do not move upstream (DFO-Canada, unpublished data). It is unknown if significant downstream migration from U.S. Red River reaches into Lake Winnipeg occurs. Continued monitoring of the Red River *Sander* stocks remains a priority, as the U.S. Red River reach monitoring does not mirror the declines observed in the lake.

Restoring river connectivity is a high priority for fisheries management in the Red River Basin. To date, seven of the eight dams on the main stem of the Red River have been modified to allow fish passage (Table 3). Drayton Dam modification began in the winter of 2022, and construction should be complete by fall of 2023. The St. Andrews Dam in Lockport, Manitoba, will then be the only barrier to upstream fish movement on the mainstem Red River, and it is passable during high water. Dams have been and continue to be modified or removed on various Red River tributaries, including the Otter Tail, Buffalo, Wild Rice, Sand Hill, Red Lake, Middle, and Roseau Rivers. To date, 40 of 77 major fish barriers have been modified. These efforts have increased access to hundreds of miles of diverse stream habitat, increased angling opportunities, and benefited the fish community for the foreseeable future.

Over exploitation, construction of dams, and declines in water quality decimated Lake Sturgeon populations in the Red River basin (MN DNR 2002). By the mid-1900’s Lake Sturgeon were effectively extirpated from the Red River basin. Lake Sturgeon restoration efforts were initiated in the Red River basin in the late 1990's with a long-range goal to re-establish a self-sustaining population (MN DNR 2002). Major components of the Lake Sturgeon Restoration Plan are the reintroduction of Lake Sturgeon at selected sites in the Red River basin using fry and fingerling stocking, fish-passage/barrier removal and modification, public information/outreach, a "catch-and-release only" regulation, and general water quality and habitat improvement and/or protection throughout the basin. Efforts to evaluate the relative success of Lake Sturgeon restoration efforts have been initiated, and signs of progress toward recovery have been noted.

Minnesota Pollution Control Agency conducts electrofishing on the Red River every 10 years as part of their large river IBI monitoring program, but COVID-19 deferrals affected their schedule. The next MPCA fish sampling will be conducted in 2026, and catches will be incorporated into the Red River Survey report the following year.

Recommendations

- Continue conducting the coordinated Red River survey every five years
    - The next survey will be in 2027.
- Revise PSD24 objectives in the Red River of the North management plan with updated targets and associated confidence interval objectives, where applicable.
    - Reach 1 PSD24 = 3 ± 2
    - Reach 2 PSD24 = 7 ± 8
    - Establish comparable objectives for Reaches 3 and 4.
- Add Channel Catfish population objectives in the Red River of the North management plan referencing:
    - Continued recruitment stability
    - Continued age 3-15 growth consistency
- Explore alternative sampling approaches to minimize systemic bias in the Red River survey, resulting from river morphology gradients and trap net usage.
    - Compare the use of un-baited hoop nets to trap nets.
    - If a gear transition is deemed beneficial:
        - Develop a conversion ratio with trap net data to maintain time series continuity with prior sampling
        - Develop PSD24 objectives for all reaches, with an emphasis on comparability
        - Develop CPUE objectives for all reaches
- Adopt survey method updates where appropriate to improve between-reach field methods consistency.
    - See content in Appendix 2 and 3.
    - Update Appendix 1 to reflect these changes, and implement in 2027; if a gear transition is deemed beneficial, provide additional updates.
- Define criteria to identify situations when further management actions are warranted if survey values fall outside of defined objectives.
    - Work with Red River Fisheries Steering Committee as appropriate.

- Continue efforts to restore aquatic connectivity through dam removal or modification projects.
- Continue to develop Lake Sturgeon assessment and monitoring programs.
- Collect information on the use and importance of tributary streams to fish species that use them to fulfill critical life history stage requirements, such as spawning.
- Identify and survey critical fish spawning habitats and over-wintering areas in the Red River basin.
- Document habitat attributes found in the Red River of the North.
- Coordinate the MN DNR 2027 Red River Channel Catfish survey and MPCA 2026 Red River biomonitoring for non-game species occurrence trends, similar to 2015 efforts.

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Figure 1. Primary rivers and streams in the Red River of the North basin.

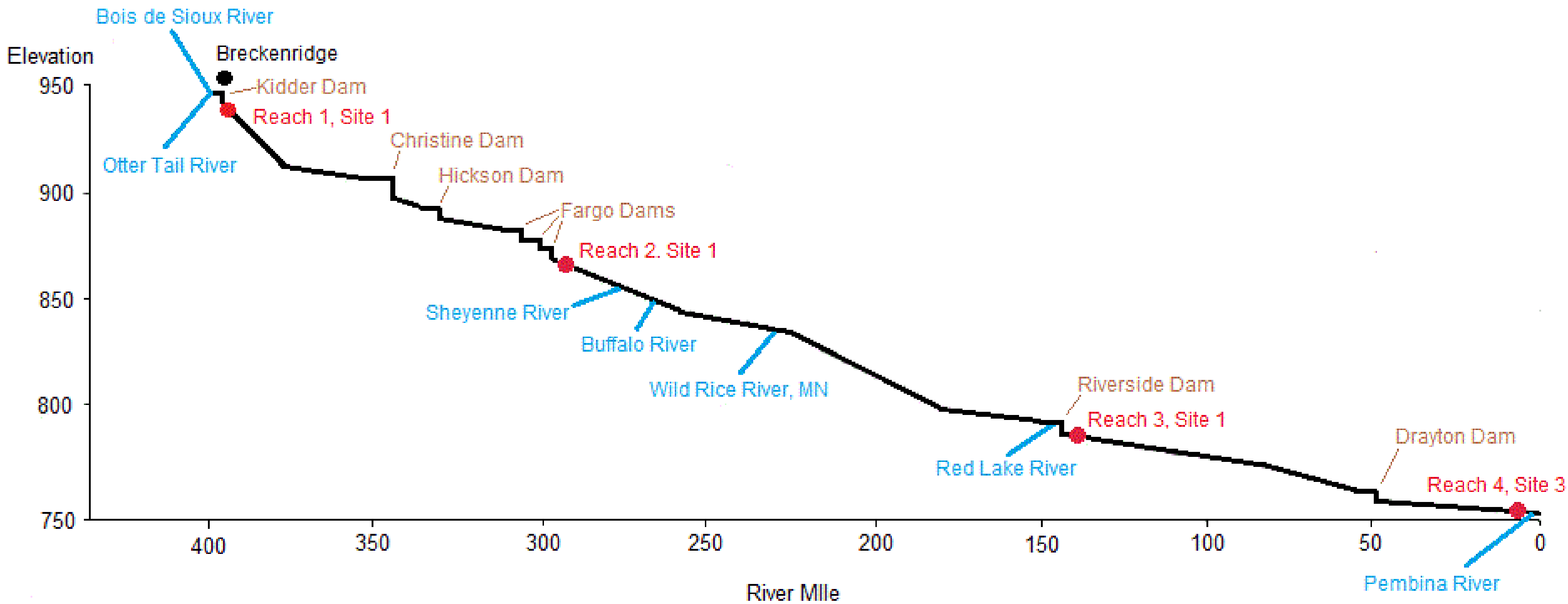


Figure 2. Red River longitudinal profile with selected reference points (modified from Renard 1986).

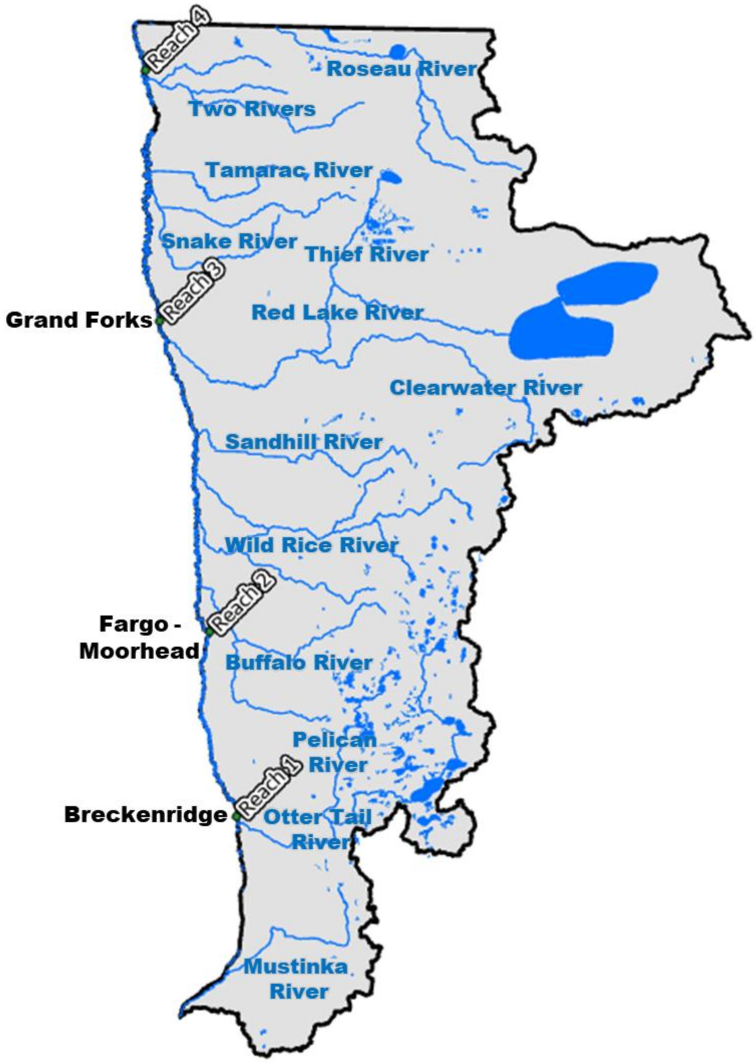


Figure 3. Red River of the North Channel Catfish survey sites, 2022.

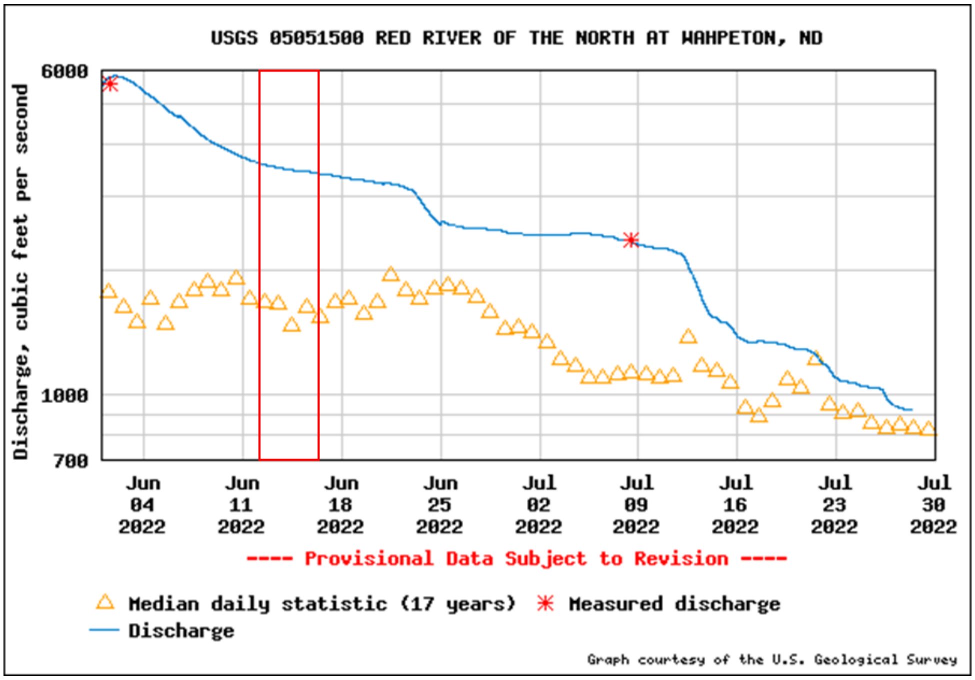


Figure 4. Red River hydrograph at the Wahpeton, ND, gage station. Sampling period (June 12-15) shown in the red frame.

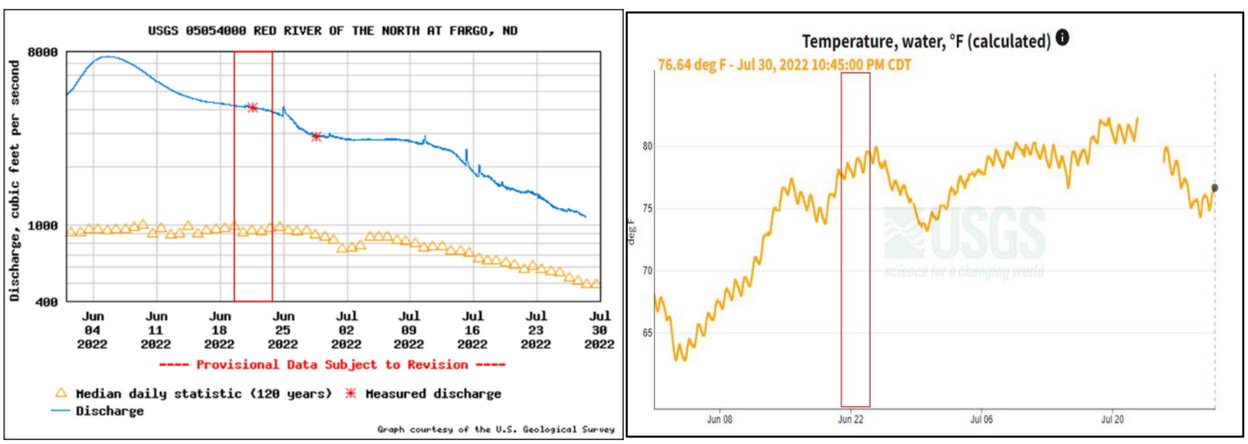


Figure 5. Red River hydrograph (L) and temperature (R) at the Fargo, ND, gage station. Sampling period (June 20-23) shown in the red frame.

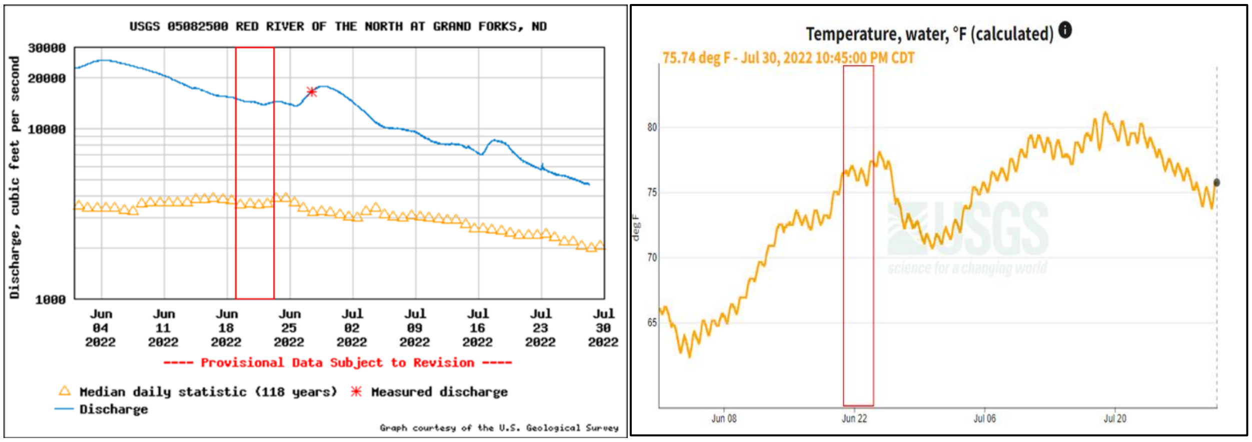


Figure 6. Red River hydrograph (L) and temperature (R) at the Grand Forks, ND, gage station. Sampling period (June 20-23) shown in the red frame.

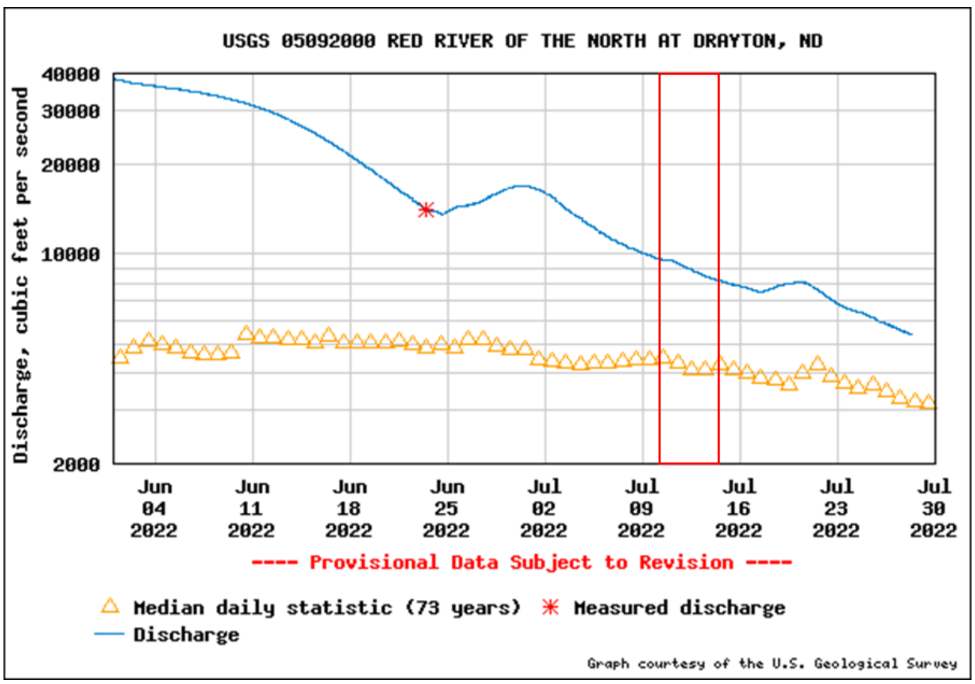


Figure 7. Red River hydrograph at the Drayton, ND, gage station. Sampling period (July 11-14) shown in the red frame.

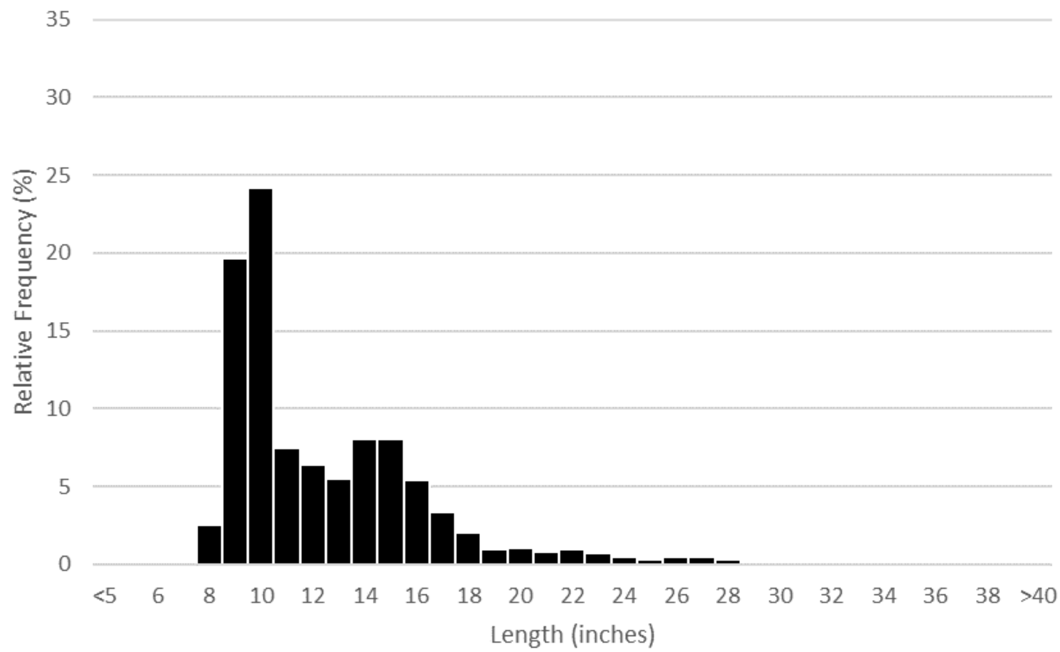


Figure 8. Channel Catfish relative length frequency distribution (n = 2576), Reach 1, Red River 2022 standard trap net sampling.

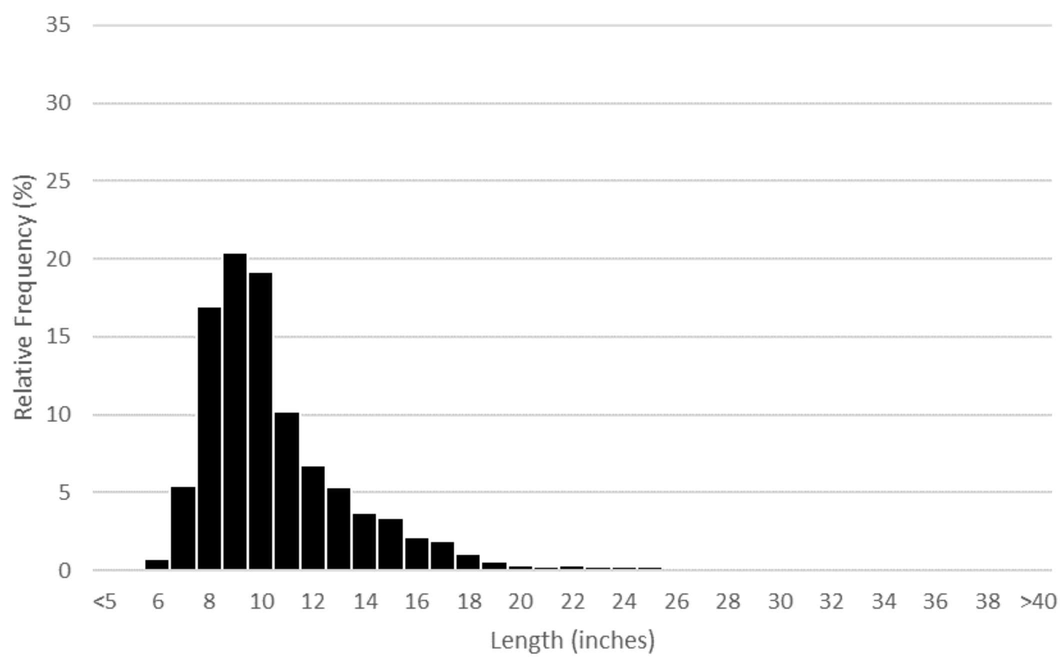
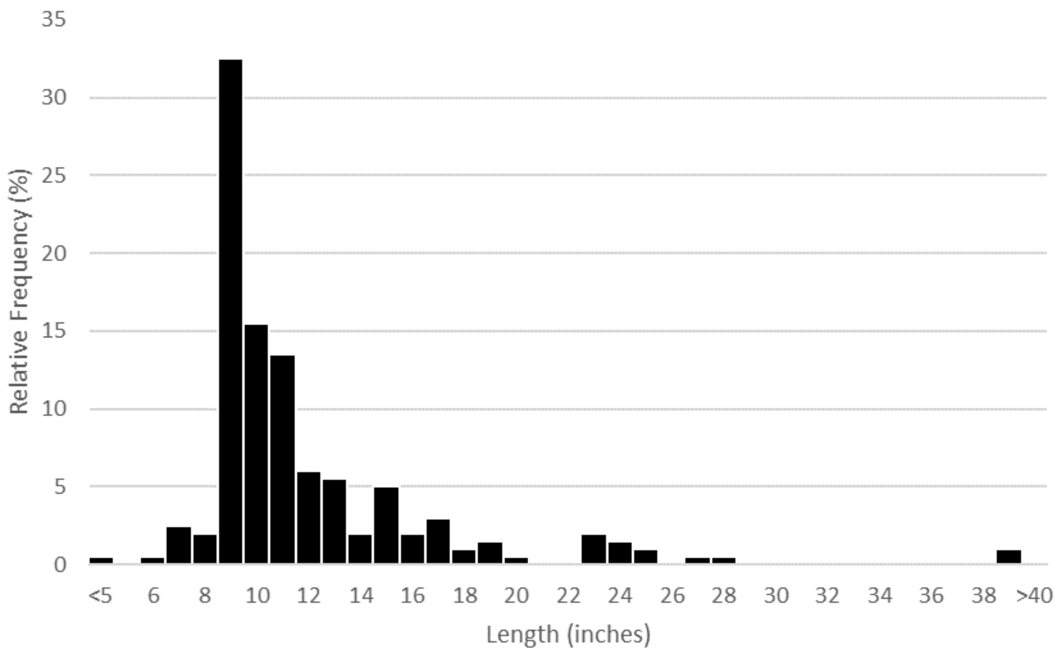


Figure 9. Channel Catfish relative length frequency distribution (n = 2266), Reach 2, Red River 2022 standard trap net sampling.



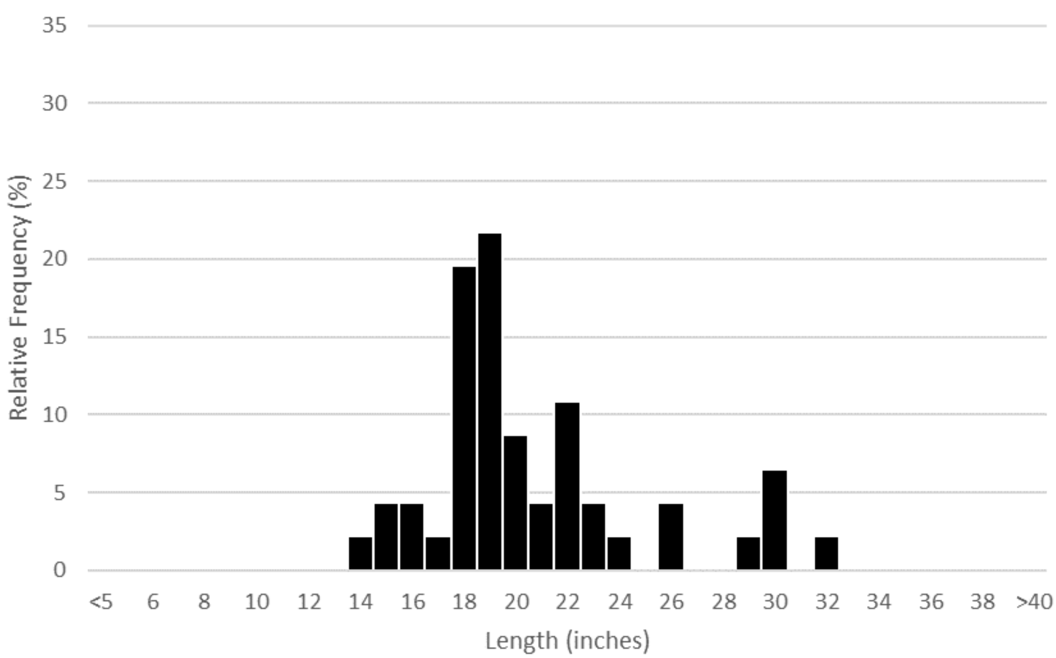


Figure 10. Channel Catfish relative length frequency distribution (n = 200), Reach 3, Red River 2022 standard trap net (top) and trot line (bottom) sampling.

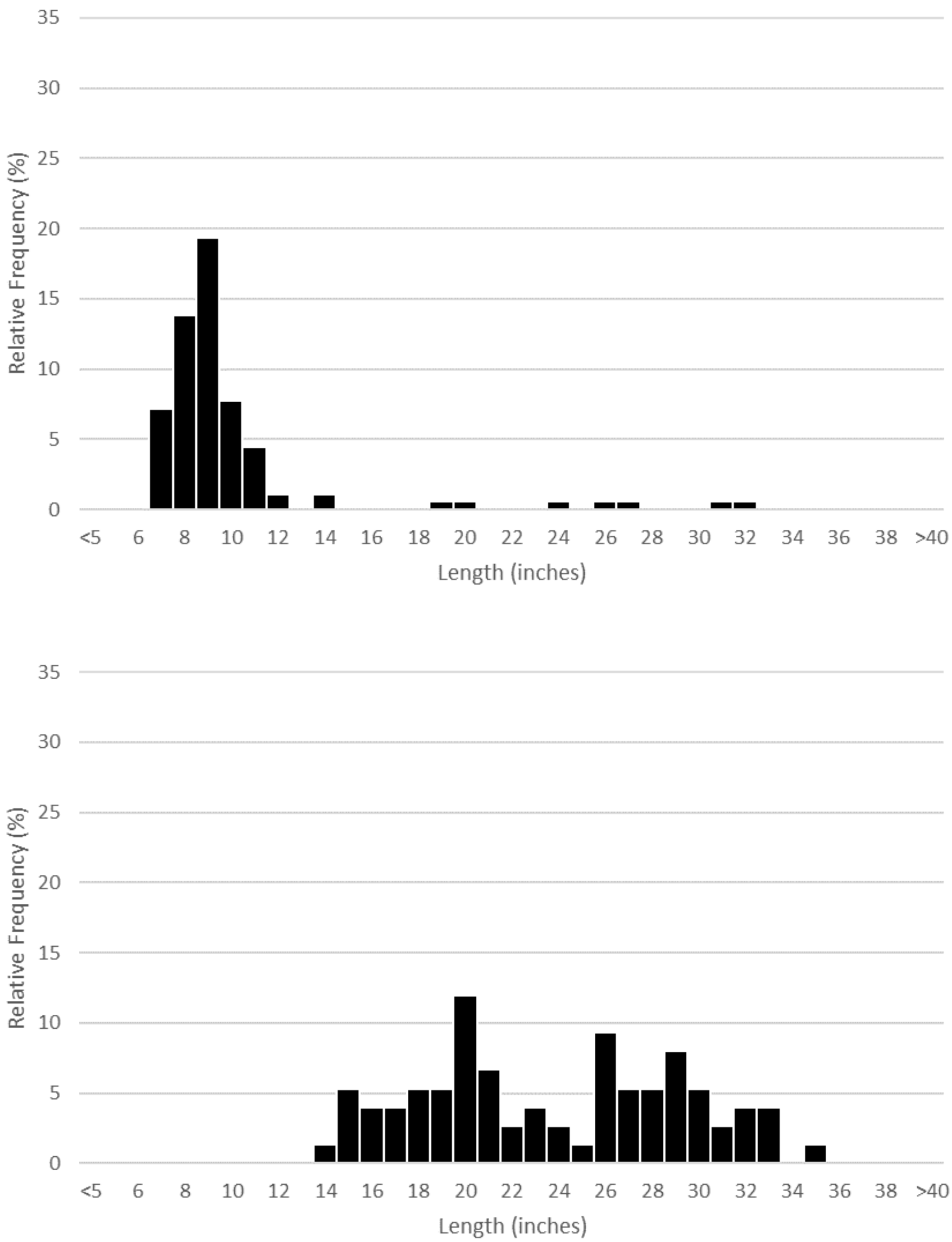
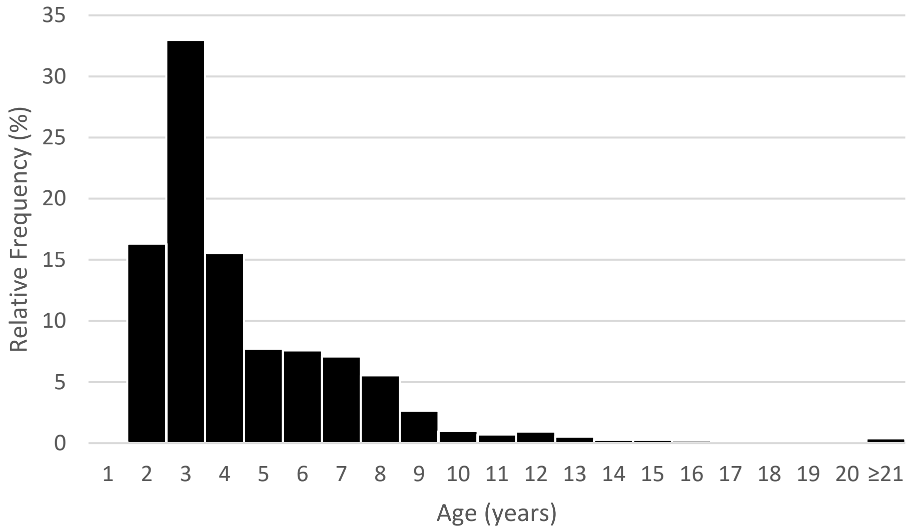


Figure 11. Channel Catfish relative length frequency distribution (n = 181), Reach 4, Red River 2022 standard trap net (top) and trot line (bottom) sampling.



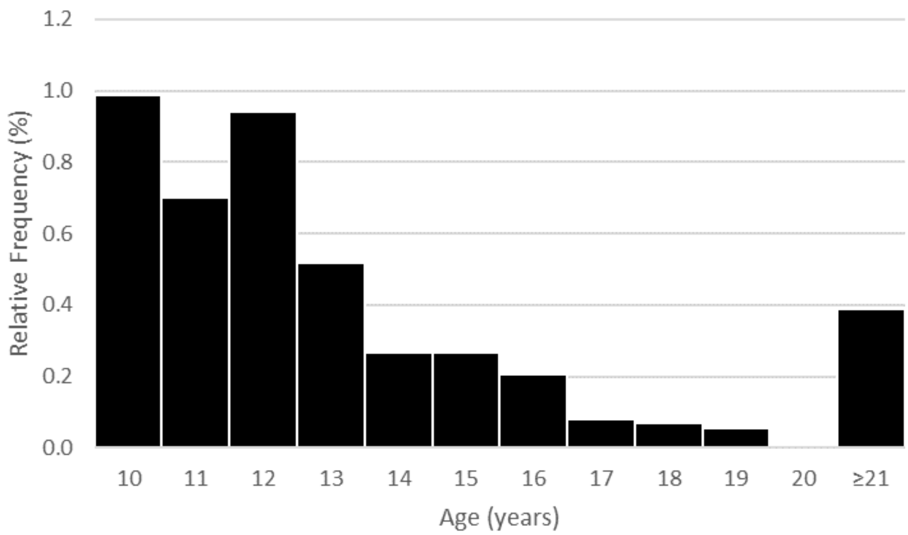


Figure 12. Relative age frequency distribution of Red River Channel Catfish, 2022 survey (top), and magnified view of relative frequencies for ages 10 – 21+ (bottom). An estimated 72.7% of Channel Catfish were under 5 years old, while ~4.5% were ≥10 years old.

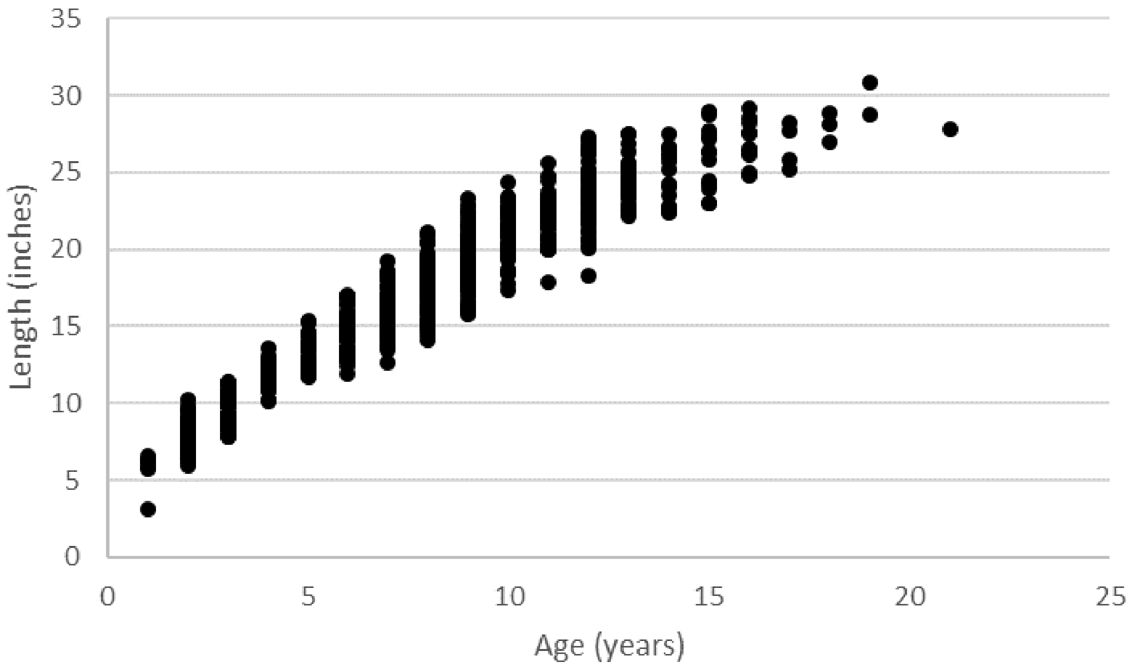


Figure 13. Length at age for all aged Channel Catfish, 2022 Red River survey.

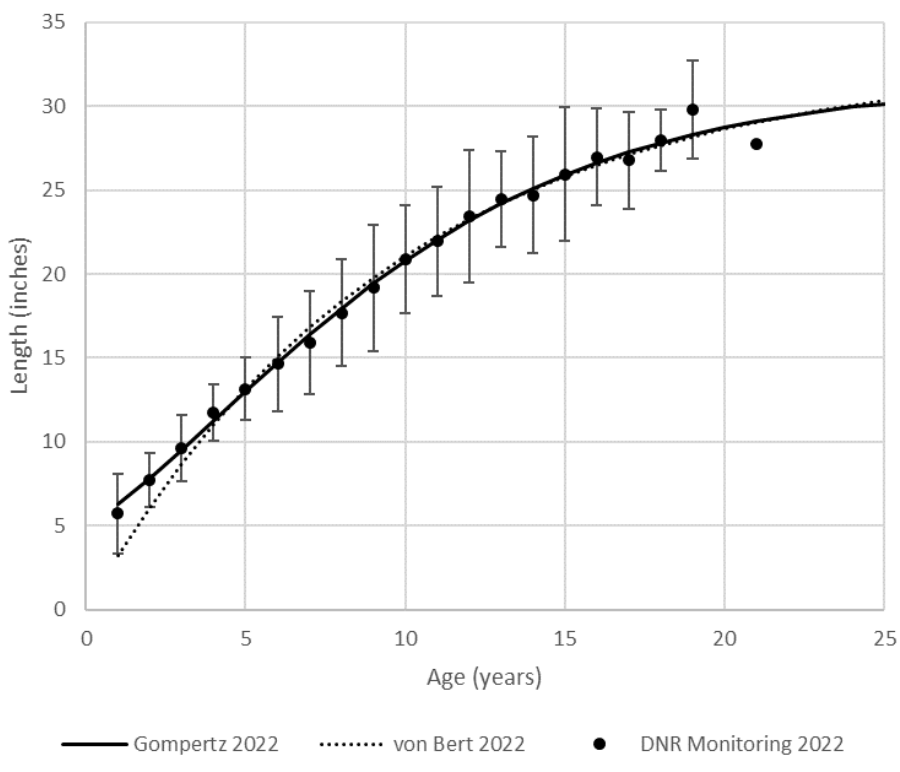


Figure 14. Gompertz and von Bertalanffy growth curve comparison, fitted to Channel Catfish mean length at age, 2022 Red River survey.

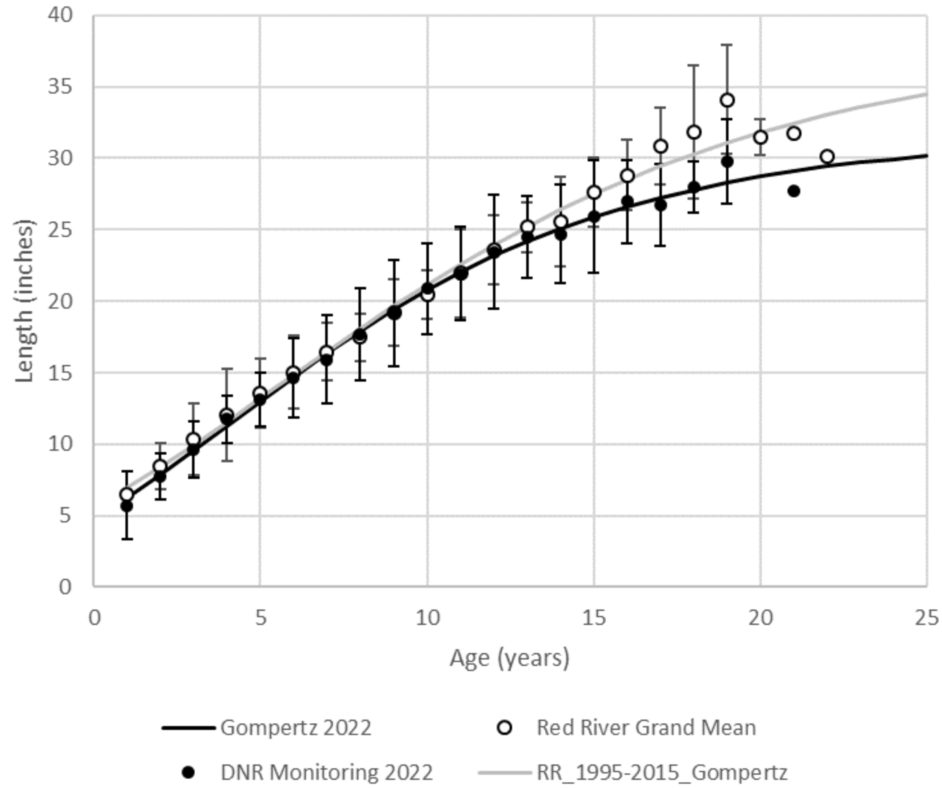


Figure 15. Gompertz growth curve comparison, using Channel Catfish mean length at age from 2022 Red River survey and 1995 – 2015 Red River surveys' grand mean length at age. Note consistency of growth rate for ages 3 - 15.

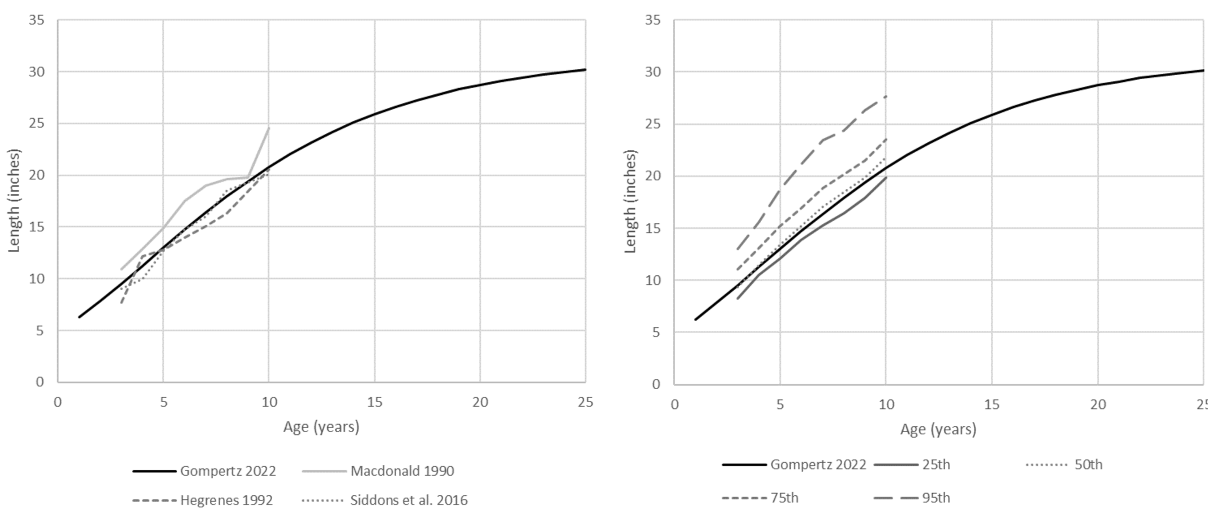


Figure 16. Gompertz – modelled Channel Catfish mean length at age, 2022 Red River survey, compared with (L) published Red River Channel Catfish aging research and (R) range-wide growth rate percentiles from Hubert (1999).

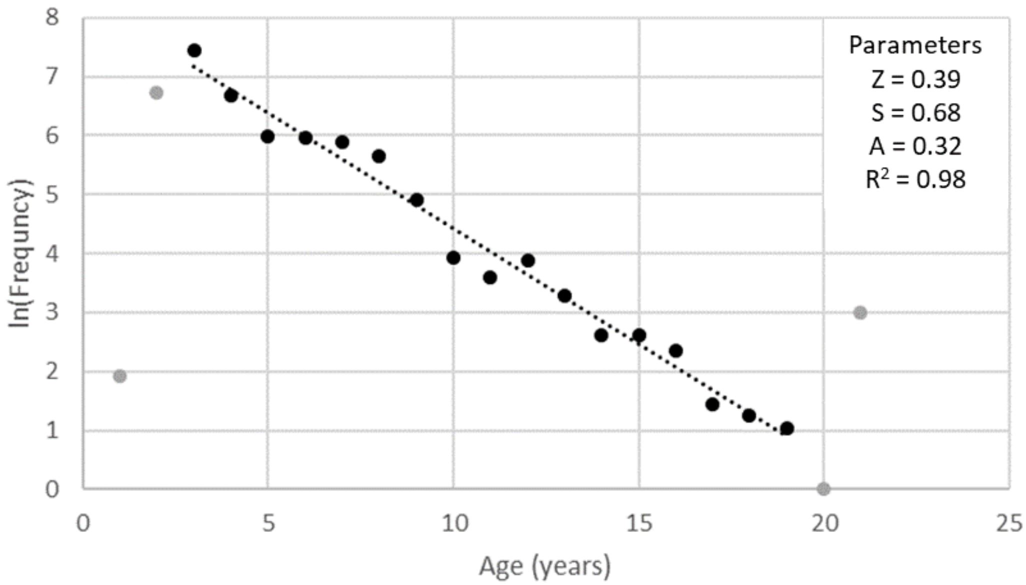


Figure 17. Channel Catfish Ricker catch curve and mortality rate estimates, using all 2022 standard trap net catches including age-length key assignment. Ages 3-19 were included in annual mortality regression (black dots). Excluded ages shown in gray. The right-most gray point is a bin of "age 21 and over" fish, and is not representative of an increase in occurrence frequency.

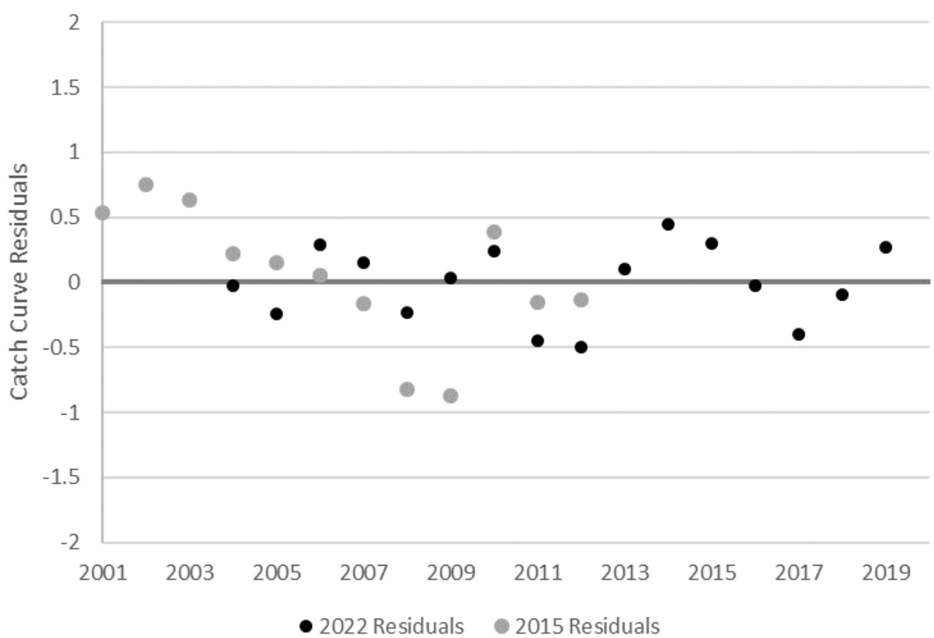


Figure 18. Channel Catfish Ricker catch curve residuals, 2022 (black); residuals derived from regression shown in Figure 17. The 2015 catch curve residuals are shown for comparison (gray). Note the oscillatory pattern similarities.

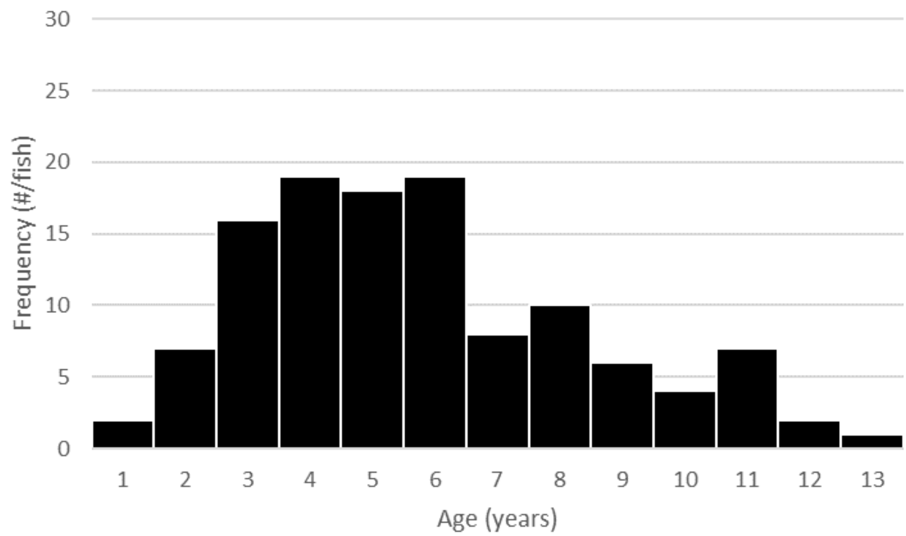


Figure 19. Sauger age frequency distribution from 2022 Red River Channel Catfish survey.

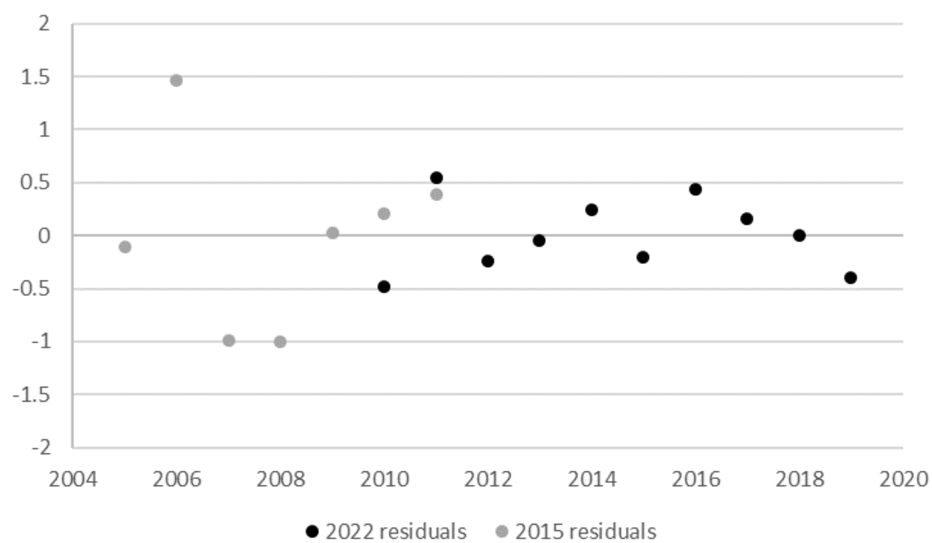


Figure 20. Sauger Ricker catch curve residuals, 2022 (black). The 2015 catch curve residuals are shown for comparison (gray).

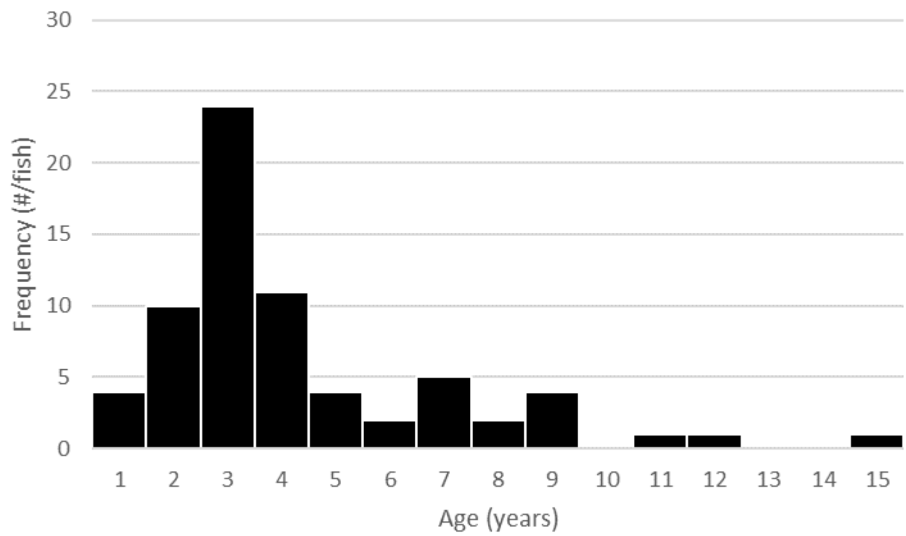


Figure 21. Walleye age frequency distribution from 2022 Red River Channel Catfish survey.

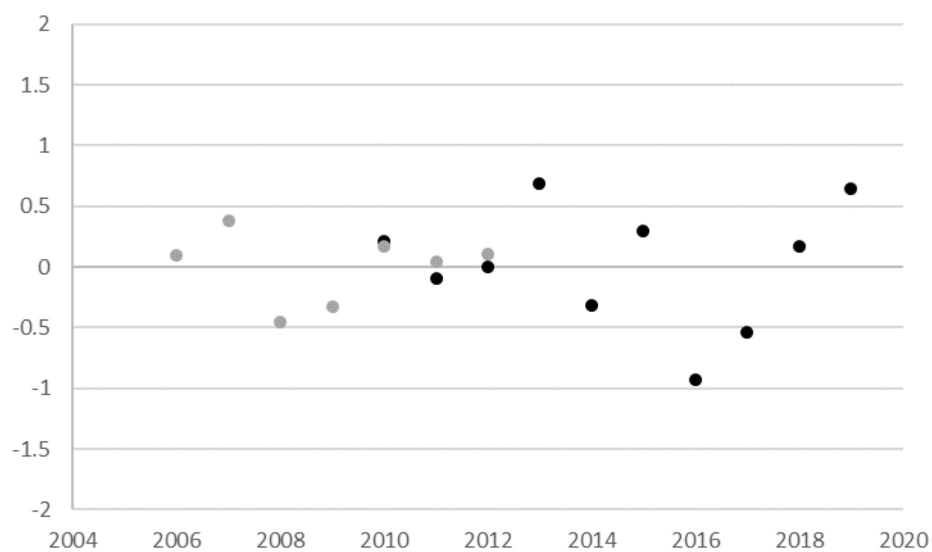


Figure 22. Walleye Ricker catch curve residuals, 2022 (black). The 2015 catch curve residuals are shown for comparison (gray).

Table 1. Red River of the North, general description of public waters.

Categories	Info
Stream Name:	Red River of the North
DNR Level 2 – HUC 4 Watershed Name:	Red River
HUC 4 Number:	902
Minnesota Kittle Number:	H-26
Location:	river mile 400.4 to river mile 0.0
Descriptive Location:	Breckenridge, MN to the US/Canadian border
Minnesota Stream Ecological Classification:	Class II (warmwater)

Table 2. Red River of the North basic geomorphology, management reaches 1 to 4.

Variable	Reach 1	Reach 2	Reach 3	Reach 4	Entire Length
Gradient (feet/mile)	0.7	0.2	0.6	0.2	0.5
Sinuosity	2.3	2.1	2	1.7	2

Table 3. Red River of the North mainstem dam locations. Since 1999, all dams on the Red River in the U.S. have been modified for fish passage, using rock arch rapids designs, except Drayton Dam. Drayton is scheduled for modification in winter of 2022-23.

Dam	Nearest Town	River Mile	Location (T.R.S.)
Drayton	Drayton, ND	49.5	T159N, R50W, sec. 18
Riverside	East Grand Forks, MN	144.6	T152N, R50W, sec. 34
Fargo North	Fargo, ND	298.3	T140N, R48W, sec. 32
Fargo Midtown	Fargo, ND	301.6	T139N, R48W, sec. 07
Fargo South	Fargo, ND	307.5	T139N, R48W, sec. 30
Hickson	Hickson, ND	332.6	T137N, R48W, sec. 19
Christine	Christine, ND	346.4	T136N, R48W, sec. 18
Kidder	Breckenridge, MN	398.0	T133N, R47W, sec. 33

Table 4. Sampling details for the 2022 Red River Channel Catfish survey. Torn nets were counted as "nulls," and no fish were counted/measured. Trotlines are susceptible to snags, breakage, and partial recovery; in these events, the recovered hooks were counted and catches scaled to the fraction of total gear fished and recovered.

Site	Dates	Number of Trap Nets	Number of Trot Lines	Reach Length (miles)
Reach 1, Site 1	June 6-10	29	0	2.18
Reach 2, Site 1	June 13-17	28	0	5.22
Reach 3, Site 1	June 20-24	30	16.04	4.05
Reach 4, Site 3	June 27-July1	30	18	3.11

Table 5. Fish species detections, Red River Channel Catfish survey 2000 - 2022.

Family/Common Name	Scientific name	2000	2005	2010	2015	2022
Petromyzontidae						
Chestnut Lamprey	*Ichthyomyzon castaneus*	X				X
Silver Lamprey	*I. unicuspis*					
Acipenseridae						
Lake Sturgeon	*Acipenser fulvescens*					
Amiidae						
Bowfin	*Amia calva*					
Hiodontidae						
Goldeye	*Hiodon alosoides*	X	X	X	X	X
Mooneye	*H. tergisis*	X	X	X	X	X
Salmonidae						
Rainbow Trout	*Oncorhynchus mykiss*					
Brown Trout	*Salmo trutta*					
Brook Trout	*Salvelinus fontinalis*					
Lake Trout	*S. namaycush*					
Catistomidae						
Quillback	*Carpoides cyprinus*	X	X	X	X	X
White Sucker	*Catostomus commersonii*	X	X	X	X	X
Northern Hog Sucker	*Hypentelium nigricans*					
Smallmouth Buffalo	*Ictiobus bubalus*					
Bigmouth Buffalo	*I. cyprinellus*	X	X	X	X	X
Silver Redhorse	*Moxostoma anisurum*	X	X	X	X	X
Golden Redhorse	*M. erythrurum*	X	X	X	X	X
Shorthead Redhorse	*M. macrolepidotum*	X	X	X	X	X
Greater Redhorse	*M. valenciennesi*	X	X	X	X	X
Cyprinidae						
Central Stoneroller	*Campostoma anomalum*					
Largescale Stoneroller	*C. oligolepis*					

Family/Common Name	Scientific name	2000	2005	2010	2015	2022
Goldfish	*Carassius auratus*					
Spotfin Shiner	*Cyprinella spiloptera*	X	X			
Common Carp	*Cyprinus carpio*	X	X	X	X	X
Brassy Minnow	*Hybognathus hankinsoni*					
Common Shiner	*Luxilus cornutus*	X				
Silver Chub	*Macrhybopsis storeiana*	X	X	X	X	X
Pearl Dace	*Margariscus margarita*					
Hornyhead Chub	*Nocomis biguttatus*					
Golden Shiner	*Notemigonus chrysoleucas*					
Pugnose Shiner	*Notropis anogenus*					
Emerald Shiner	*N. atherinoides*	X	X			
River Shiner	*N. blennius*					
Bigmouth Shiner	*N. dorsalis*					
Blackchin Shiner	*N. heterodon*					
Blacknose Shiner	*N. heterolepis*					
Spottail Shiner	*N. hudsonius*					
Carmine Shiner	*N. percobromus*					
Sand Shiner	*N. stramineus*					
Weed Shiner	*N. texanus*					
Mimic Shiner	*N. volucellus*					
Northern Redbelly Dace	*Phoxinus eos*					
Finescale Dace	*Phoxinus neogaeus*					
Bluntnose Minnow	*Pimephales notatus*					
Fathead Minnow	*P. promelus*	X				
Flathead Chub	*Platygobio gracilis*					
Western Blacknose Dace	*Rhinichthys obtusus*					
Longnose Dace	*R. cataractae*					
Creek Chub	*Semotilus atromaculatus*					
Ictaluridae						
Black Bullhead	*Ameiurus melas*	X	X	X	X	X
Yellow Bullhead	*A. natalis*	X	X	X	X	X
Brown Bullhead	*A. nebulosus*	X	X	X	X	X
Channel Catfish	*Ictalurus punctatus*	X	X	X	X	X
Stonecat	*Noturus flavus*	X	X	X	X	X
Tadpole Madtom	*N. gyrinus*	X			X	X
Umbridae						
Central Mudminnow	*Umbra limi*					
Esocidae						
Northern Pike	*Esox lucius*	X	X	X	X	X
Muskellunge	*E. masquinongy*					
Osmeridae						
Rainbow Smelt	*Osmerus mordax*					

Family/Common Name	Scientific name	2000	2005	2010	2015	2022
Cyprinodontidae						
Banded Killifish	*Fundulus diaphanus*		X			
Gadidae						
Burbot	*Lota lota*	X	X	X	X	
Percopsidae						
Trout-perch	*P.omiscomaycus*	X	X			
Moronidae						
White Bass	*Morone chrysops*	X	X			
Centrarchidae						
Rock Bass	*Ambloplites rupestris*	X	X	X	X	X
Green Sunfish	*Lepomis cyanellus*	X			X	
Pumpkinseed	*L. gibbosus*					
Orangespotted Sunfish	*L. humilis*	X	X			X
Bluegill	*L. macrochirus*		X	X		X
Smallmouth Bass	*Micropterus dolomieu*	X	X	X	X	X
Largemouth Bass	*M. salmoides*					
White Crappie	*Pomoxis annularis*					
Black Crappie	*P. nigromaculatus*	X	X	X	X	X
Percidae						
Rainbow Darter	*Etheostoma caeruleum*					
Iowa Darter	*E. exile*					
Least Darter	*E. microperca*					
Johnny Darter	*E. nigrum*					
Logperch	*Percina caprodes*					
Blackside Darter	*P. maculata*					
River Darter	*P. shumardi*					
Yellow Perch	*Perca flavescens*	X	X			
Sauger	*Sander Canadensis*	X	X	X	X	X
Walleye	*S. vitreus*	X	X	X	X	X
Sciaenidae						
Freshwater Drum	*Aplodinotus grunniens*	X	X	X	X	X
Cottidae						
Slimy Sculpin	*Cottus cognatus*					
Mottled Sculpin	*C. bairdii*					
Spoonhead Sculpin	*C. ricei*					
Gasterosteidae						
Brook Stickleback	*Culea inconstans*					
Ninespine Stickleback	*Pungitius pungitius*					
Total number of species		**35**	**32**	**25**	**26**	**27**

Table 6. Frequency and catch rates of fishes sampled using standard trap nets, 2022 Red River Channel Catfish survey.

	Reach 1		Reach 2		Reach 3		Reach 4	
Family/Species	Count	CPUE	Count	CPUE	Count	CPUE	Count	CPUE
Catastomidae								
Bigmouth Buffalo	1	0.03			1	0.03		
General: Redhorses								
Golden Redhorse	1	0.03	16	0.57	6	0.20	5	0.17
Greater Redhorse	2	0.07			3	0.10		
Quillback	10	0.34	478	17.07	75	2.50	237	7.90
Shorthead Redhorse	55	1.90	64	2.29	36	1.20	70	2.33
Silver Redhorse	14	0.48	24	0.86	15	0.50	15	0.50
White Sucker	1	0.03	21	0.75	19	0.63	59	1.97
Centrarchidae								
Black Crappie	1	0.03					7	0.23
Bluegill	12	0.41	40	1.43	1	0.03		
Orangespotted Sunfish			1	0.04				
Rock Bass	30	1.03	1	0.04	3	0.10	1	0.03
Smallmouth Bass	6	0.21	3	0.11	1	0.03		
Cyprinidae								
Common Carp	4	0.14	11	0.39	14	0.47	6	0.20
Silver Chub							1	0.03
Esocidae								
Northern Pike	4	0.14	2	0.07				
Hiodontidae								
Goldeye	338	11.66	250	8.93	89	2.97	205	6.83
Mooneye	4	0.14	1	0.04				
Ictaluridae								
Black Bullhead	44	1.52	372	13.29	12	0.40	47	1.57
Brown Bullhead			20	0.71				
Channel Catfish	4445	153.28	2866	102.36	249	8.30	184	6.13
Stonecat	1	0.03	1	0.04	9	0.30	4	0.13
Tadpole Madtom			1	0.04				
Yellow Bullhead	1	0.03	6	0.21			2	0.07
Percidae								
Sauger			19	0.68	73	2.43	27	0.90
Walleye	10	0.34	26	0.93	32	1.07	8	0.27
Petromyzontidae								
Chestnut Lamprey			1	0.04				
Scianidae								
Freshwater Drum	11	0.38	73	2.61	164	5.47	325	10.83

Table 7. Channel Catfish length frequency, 2022 Red River Channel Catfish survey trap nets.

	Reach 1		Reach 2		Reach 3		Reach 4	
TL (inches)	Count	Relative Freq (%)	Count	Relative Freq (%)	Count	Relative Freq (%)	Count	Relative Freq (%)
<5			2	0.1	1	0.5		
5-<6			3	0.1				
6-<7			17	0.8	1	0.5		
7-<8	1	0.0	124	5.5	5	2.5	13	12.3
8-<9	66	2.6	385	17.0	4	2.0	25	23.6
9-<10	506	19.6	462	20.4	65	32.5	35	33.0
10-<11	623	24.2	435	19.2	31	15.5	14	13.2
11-<12	193	7.5	232	10.2	27	13.5	8	7.5
12-<13	165	6.4	153	6.8	12	6.0	2	1.9
13-<14	142	5.5	122	5.4	11	5.5		
14-<15	207	8.0	84	3.7	4	2.0	2	1.9
15-<16	208	8.1	76	3.4	10	5.0		
16-<17	140	5.4	49	2.2	4	2.0		
17-<18	86	3.3	43	1.9	6	3.0		
18-<19	52	2.0	25	1.1	2	1.0		
19-<20	25	1.0	14	0.6	3	1.5	1	0.9
20-<21	27	1.0	7	0.3	1	0.5	1	0.9
21-<22	20	0.8	5	0.2				
22-<23	25	1.0	8	0.4				
23-<24	19	0.7	6	0.3	4	2.0		
24-<25	13	0.5	5	0.2	3	1.5	1	0.9
25-<26	8	0.3	5	0.2	2	1.0		
26-<27	13	0.5					1	0.9
27-<28	13	0.5			1	0.5	1	0.9
28-<29	8	0.3	1	0.0	1	0.5		
29-<30	4	0.2	1	0.0				
30-<31	4	0.2	2	0.1				
31-<32							1	0.9
32-<33	3	0.1					1	0.9
33-<34	4	0.2						
34-<35								
35-<36								
36-<37	1	0.0						
37-<38								
38-<39								
39-<40					2	1.0		
>40								
Mean (inches)	13.0		11.1		12.4		10.5	
Count	2576		2266		200		106	

Table 8. Channel Catfish length frequency, 2022 Red River Channel Catfish survey trot lines.

	Reach 3		Reach 4	
TL (inches)	Count	Relative Freq (%)	Count	Relative Freq (%)
<5				
5-<6				
6-<7				
7-<8				
8-<9				
9-<10				
10-<11				
11-<12				
12-<13				
13-<14				
14-<15	1	2.2	1	1.3
15-<16	2	4.3	4	5.3
16-<17	2	4.3	3	4.0
17-<18	1	2.2	3	4.0
18-<19	9	19.6	4	5.3
19-<20	10	21.7	4	5.3
20-<21	4	8.7	9	12.0
21-<22	2	4.3	5	6.7
22-<23	5	10.9	2	2.7
23-<24	2	4.3	3	4.0
24-<25	1	2.2	2	2.7
25-<26			1	1.3
26-<27	2	4.3	7	9.3
27-<28			4	5.3
28-<29			4	5.3
29-<30	1	2.2	6	8.0
30-<31	3	6.5	4	5.3
31-<32			2	2.7
32-<33	1	2.2	3	4.0
33-<34			3	4.0
34-<35				
35-<36			1	1.3
36-<37				
37-<38				
38-<39				
39-<40				
>40				
Mean (inches)	21.1		24.2	
Count	46		75	

Table 9. **Red River Channel Catfish survey trap net CPUE, 1995 to present. Catch rates from 30 core nets only, as supplemental nets were fished some years for varying purposes. The moving average of the prior three surveys included for comparison, and intended to dampen environmental effects on long-term CPUE.**

	Reach 1	Reach 2	Reach 3	Reach 4
2022	153.3	102.4	8.3	6.0
2015*	40.3	12.9	2.0	2.2
2010*	74.6	22.9	0.9	5.5
2005*	82.2	40.6	8.0	1.4
2000	13.4	10.4	2.6	3.0
1995	38.6	64.5	0.0	0.4
Three Survey Moving Average*	65.7	25.5	3.6	3.0

Table 10. **Reach 1, Site 1 Red River Channel Catfish size distribution indices, trap net catches 1995 to present.**

	N	PSD	PSD20	PSD24	PSD30
2022	2576	34	12	5	<1
2015	1160	26	10	3	<1
2010	1410	37	9	2	<1
2005	49	31	6	2	0
2000	163	61	25	4	0
1995	243	47	15	2	0

Table 11. **Reach 2, Site 1 Red River Channel Catfish size distribution indices, trap net catches 1995 to present.**

	N	PSD	PSD20	PSD24	PSD30
2022	2266	20	5	2	<1
2015	447	42	23	9	4
2010	505	67	26	9	1
2005	507	50	36	18	8
2000	89	60	35	16	2
1995	720	42	21	7	1

Table 12. **Channel Catfish trot line CPUE (#/night), Red River surveys 1995 - present. The moving average of the prior three surveys included for comparison, and intended to dampen environmental effects on long-term CPUE.**

	Reach 3	Reach 4	Reach 3, ≥ 24 inches	Reach 4, ≥ 24 inches
2022	2.9	4.4	0.5	2.1
2015*	1.9	3.3	1.4	2.6
2010*	3.2	5.1	1.9	3.6
2005*	4.4	3.4	1.3	1.6
2000	8.5	4.5	2.2	1.8
1995	2.3	3.1	0.8	2.0
Prior 3 Surveys Moving Average*	3.2	3.9	1.5	2.6

Table 13. Reach 3, Site 1 Red River Channel Catfish stock density indices, trot line catches 2005 to present

	N	PSD	PSD20	PSD24	PSD30
2022	46	93	46	17	9
2015	56	98	84	45	11
2010	88	97	73	40	7
2005	78	100	94	78	41

Table 14. Reach 4, Site 3 Red River Channel Catfish stock density indices, trot line catches 2005 to present

	N	PSD	PSD20	PSD24	PSD30
2022	75	93	75	49	17
2015	99	99	88	46	16
2010	104	98	89	63	10
2005	101	100	95	77	21

Table 15. Scheels Boundary Battle catfish tournament weigh-in results (pounds). Tournament occurs in Reach 3. The 2022 event followed standard sampling by 1 day, during which time a major rainstorm occurred. Two day tournament is typically held in late June, and is capped at 50 boats. Teams weigh in two catfish over 24" and one under 24" per day, with daily possession of 3 fish.

	Winning 2-day bag	Average of Top 10 2-day bag limits	"Big Fish" side pot
2022	75.2	70.8	21.8
2021	65.3	62.1	18.1
2020	68.7	63.3	20.1
2019	51.3	44.3	18.6
2018	66.4	56.2	19.7
2017	61.7	50.6	22.3
2016	72.2	69.7	21.6

Table 16. Estimated annual mortality rates, Red River Channel Catfish. Field and quantitative methods vary; estimates presented for general comparison.

Annual Mortality	Citation
0.32	*this study* 2022
0.16	Hanson 2019
0.24	Wendel 2016
0.19	Siddons et al. 2016
0.18	Hegrenes 1992
0.09	Macdonald 1990

Table 17. Sauger length frequency, 2022 Red River Channel Catfish survey trap nets.

	Reach 1		Reach 2		Reach 3		Reach 4	
TL (inches)	Count	Relative Freq (%)	Count	Relative Freq (%)	Count	Relative Freq (%)	Count	Relative Freq (%)
<5								
5-<6								
6-<7								
7-<8								
8-<9							2	7.4
9-<10					1	1.4		
10-<11					9	12.3	2	7.4
11-<12			1	5.3	20	27.4	7	25.9
12-<13			4	21.1	17	23.3	10	37.0
13-<14			3	15.8	9	12.3	4	14.8
14-<15			5	26.3	15	20.5	1	3.7
15-<16			4	21.1	1	1.4	1	3.7
16-<17			2	10.5	1	1.4		
17-<18								
18-<19								
19-<20								
20-<21								
21-<22								
22-<23								
23-<24								
24-<25								
25-<26								
26-<27								
27-<28								
28-<29								
29-<30								
30-<31								
31-<32								
32-<33								
33-<34								
34-<35								
35-<36								
36-<37								
37-<38								
38-<39								
39-<40								
40-<41								
Mean (inches)			14.2		12.6		12.1	
Count			19		73		27	

Table 18. Walleye length frequency, 2022 Red River Channel Catfish survey trap nets.

	Reach 1		Reach 2		Reach 3		Reach 4	
TL (inches)	Count	Relative Freq (%)	Count	Relative Freq (%)	Count	Relative Freq (%)	Count	Relative Freq (%)
<5								
5-<6								
6-<7								
7-<8								
8-<9			3	12.0			1	12.5
9-<10			2	8.0			1	12.5
10-<11			1	4.0				
11-<12					1	3.2		
12-<13			3	12.0	6	19.4	1	12.5
13-<14			3	12.0	12	38.7	2	25.0
14-<15	3	30.0	2	8.0	6	19.4		
15-<16	1	10.0	1	4.0	4	12.9	1	12.5
16-<17	3	30.0	3	12.0	1	3.2		
17-<18			2	8.0	1	3.2		
18-<19			1	4.0			1	12.5
19-<20			2	8.0				
20-<21			1	4.0				
21-<22								
22-<23							1	12.5
23-<24								
24-<25			1	4.0				
25-<26	1	10.0						
26-<27								
27-<28								
28-<29	2	20.0						
29-<30								
30-<31								
31-<32								
32-<33								
33-<34								
34-<35								
35-<36								
36-<37								
37-<38								
38-<39								
39-<40								
>40								
Mean (inches)	19.2		14.6		14.0		14.4	
Count	10		25		31		8	

Appendix I – Red River survey methods , 2010

Red River of the North

Channel Catfish Survey Methodology

Tom Groshens
Red River Fisheries Specialist
Minnesota Dept. Natural Resources

June 7, 2010

Red River of the North
Channel Catfish Survey Methodolgy

Background

The coordinated Red River of the North (Red River) fish survey has been conducted three times (1995, 2000, and 2005) over the past 15 years (Henry 1996, Huberty 1996, Topp 1996, Martini and Stewig 2002, Henry 2007). These, along with the assessments done by Topp et al. (1994), Hegrenes (1992), McDonald (1990) and Wendel (1999) have provided valuable baseline information on the channel catfish population and, to a lesser extent, other fishes found in the mainstem of Red River. The surveys also provided insight into how to effectively and efficiently sample channel catfish along the 400 miles of large river habitat in a manner that will provide useful information to those responsible for managing the Red River fishery.

Fisheries professionals reviewed the information obtained from the above mentioned surveys and, through several meetings and discussions held in 2009 and 2010, implemented a number of modifications to the initial survey design that are intended to improve the quality and usefulness of the data. It was anticipated that the modifications will provide better monitoring information on the Red River catfish population and help ensure that resources expended are used in a cost effective and efficient manner given the amount of resources available.

The purpose of this survey is to provide accurate information on the Red River channel catfish population(s) sufficient to guide management decisions in order to achieve the population goals and objectives as outlined in the Red River of the North Fisheries Management Plan (MN DNR et al. 2008). The survey's primary focus is on channel catfish population size (length and weight) structure, with special emphasis on larger (≥ 20 inches TL) fish.

Red River Channel Catfish Survey Methods

A. <u>Timing</u>

The survey is focused on channel catfish and previous efforts have shown early June to be an effective time period for sampling Red River catfish, likely because this time coincides with spawning behavior and/or seasonal high flows. Therefore, sampling will continue to be targeted for a two week period in early June. Exact sample dates may vary depending on river conditions. Sampling frequency will be maintained on a 5 year schedule; sampling is planned for 2010, 2015, etc.

B. <u>Reaches</u>

Red River was divided into four fisheries management reaches for channel catfish surveying and reporting (Figure 1, Table 1; Topp et al. 1994). The length of each river reach is based primarily on administrative considerations with specific reach boundaries strategically placed to coincide with major river hydrologic and biological features (dams) near the administrative boundaries. Since the time the Reach boundaries were first established, the dams at Wahpeton/Breckenridge, Fargo/Moorhead, and Grand Forks/East Grand Forks have all been modified into rock-arch-rapids and now allow for fish passage at all flows. Regardless, it was determined that the Reach boundaries would remain the same for consistency and the initial Reaches will be used ad reference for all sampling associated with this survey.

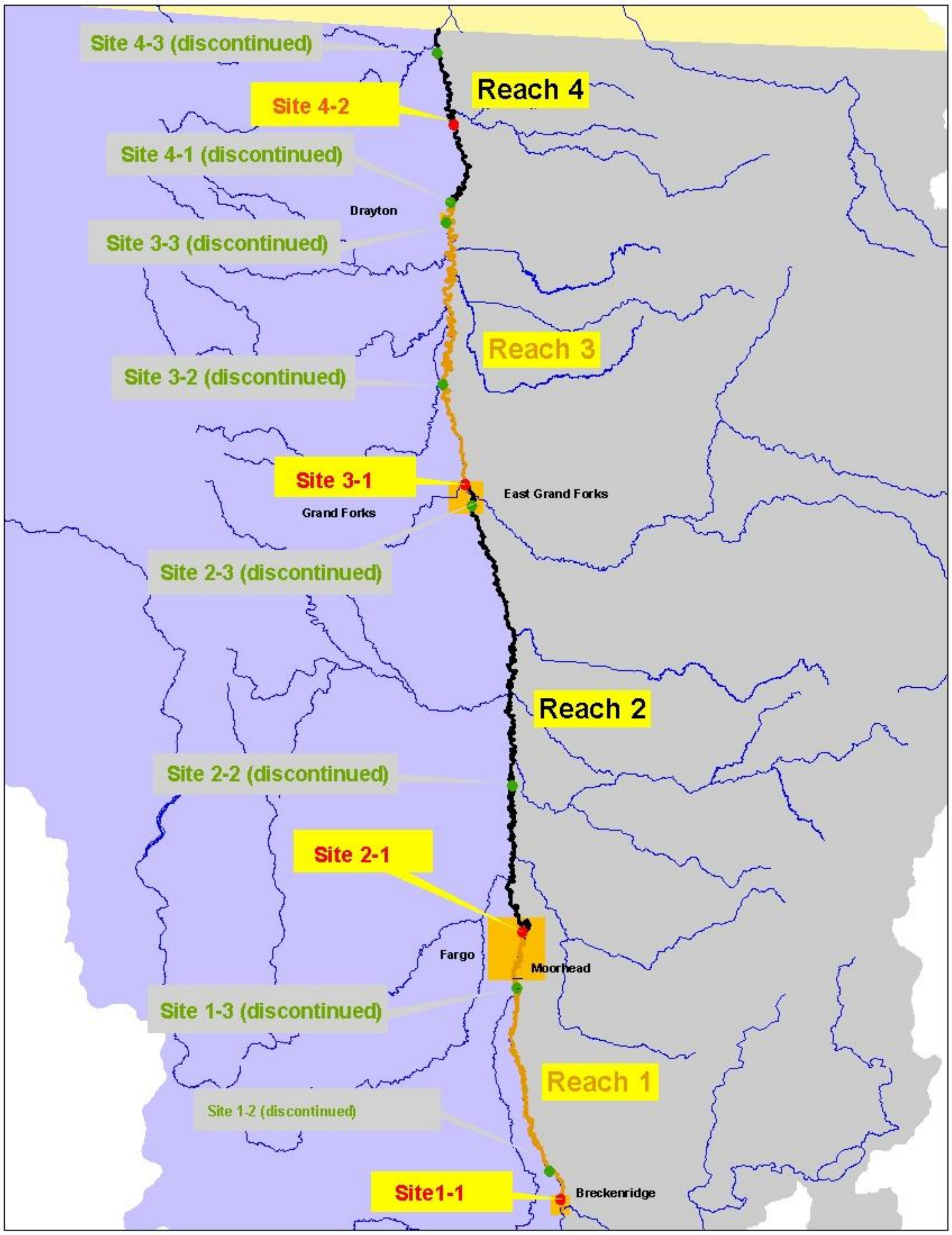


Figure 1. Red River reaches and sample site locations.

Table 1. Description of Red River management Reaches.

Reach Number	Upstream Boundary	Downstream Boundary	Length (river miles)
1	RM 400.4 Confluence of Otter Tail and Bois de Sioux rivers	RM 307.5 Fargo North Dam (modified)	92.9
2	RM 307.5 Fargo North Dam (modified)	RM 144.6 Riverside Dam (modified), Grand Forks	162.6
3	RM 144.6 Riverside Dam (modified), Grand Forks	RM 49.5 Drayton Dam	95.1
4	RM 49.5 Drayton Dam	RM 0.0 U.S. / Canada border	49.5

C. Sample Sites

A sample "site" refers to a segment of river wherein a number of trap nets and trotlines, or other gear as determined appropriate, are deployed for sampling channel catfish during this survey. Sites to be sampled for long-term channel catfish population monitoring will be:

Reach 1, Site 1

Reach 1, Site 1 is a 2.4 mile long site with its upstream boundary at the Kidder Dam rapids (Figure 1 and Appendix I, Figure A1).

Reach 2, Site 1

Reach 2, Site 1 is a 5.5 mile site with its upstream boundary located 1.5 miles upstream from the access located at M.B. Johnson Park in Moorhead (Figure 1 and Appendix I, Figure A2).

Reach 3, Site 1

Reach 3, Site 1 is a 4.0 mile site with its upstream boundary located 1.1 miles downstream from Riverside Dam rapids in Grand Forks (Figure 1 and Appendix I, Figure A3).

Reach 4, Site 2

Reach 4, Site 2 is a 3.0 mile site with its upstream boundary located 1.5 miles upstream from the access at Highway 175 west of Hallock (Figure 1 and Appendix I, Figure A4)

D. Stations, Gear and Effort

An individual trap net or trotline set location within a site is referred to as a sample "station". It has been assumed that the Red River survey coincides with the major channel catfish spawning migration for the year. Therefore, it is recommended that stations within a site be sampled in an upstream to downstream progression in an attempt to reduce the possibility of recapturing catfish.

1. Trap Nets

Minnesota DNR standard, non-baited trap nets (91 x 183 cm frame, 1.9 cm bar-mesh, 12.2 m x 0.75 m lead) will be used to sample channel catfish. There will be 30 trap net sample station locations distributed as evenly as possible throughout a sample site with the intent of collecting a representative sample of channel catfish. To facilitate net setting, each site will be divided into 30 equal-length segments and reference points for trap net set locations were plotted in the center of each segment (Appendix I, Figures A1 through A4). Field crews should use a GPS unit to navigate to each reference point and set a trap net at a suitable location as close as possible to the given point. Nets should be set no farther than one-half the distance (either upstream or downstream) to adjacent reference points. Exact net locations should be chosen to maximize the number of channel catfish caught in each trap net set. It is recognized that some nets will be set in what may be considered lower quality channel catfish habitat at the time (e.g., runs, glides) and channel catfish catches in these nets may be lower than nets set in what is considered higher quality habitats (e.g., log jam in a pool on the outside of a meander bend).

Trap nets are set by anchoring the pot end on the shoreline using the best manner possible (e.g., attaching to woody debris or staking), attaching a fluke anchor to the lead (10 lbs. recommended) and stretching the lead downstream at an approximately 45-degree angle relative to shore; the angle may be less where necessary based on water velocity. Complete the trap net and trotline set/lift data form for each sample station (Appendix II). GPS coordinates for each individual trap net station will be recorded both on the set/lift data and in the GPS unit as a waypoint.

Each trap net will be fished for only one night; trap nets will not be reset at the same location. If a net set is determined to be invalid (biased) for any reason, such as a hole in net or the frame had collapsed, data will not be taken on fish from that net. The net will be emptied, repaired or replaced, and reset at that sample location until a valid net set has been sampled. If the required number of trap net sets (30) has been completed and less than 100 channel catfish greater than or equal to 20 inches TL were captured and recorded, then supplemental nets can be set and fished at any location within the site until the minimum sample size of fish is achieved. Data will still be collected on all fish in supplemental trap nets, however, only information from the original 30 sets will be used to construct and analyze channel catfish abundance indices (e.g., CPUE).

2. Trotlines

Trotlines to be used for sampling catfish will be 45 m long with 25 size 4/0 hooks on 0.3 m dropper lines. There will be 18 trotline sample stations distributed as evenly as possible throughout a sample site where trotlines are used. To facilitate trotline setting, each site was divided into 18 equal-length segments and reference points for line set locations were plotted in the center of each segment (Appendix I, Figures A5 and A6). Field crews should use a GPS unit to navigate to each reference point and set a trotline at a suitable location as close as possible to the given point. Trotlines should be set no farther than one-half the distance (either upstream or downstream) to adjacent reference points. Exact trotline locations should be chosen to maximize the number of channel catfish caught on each line set. It is recognized that some trotlines will be set in what may be considered lower quality channel catfish habitat at the time (e.g., runs, glides) and channel catfish catches on these lines may be lower than lines set in what is considered higher quality habitats (e.g., log jam in a pool on the outside of a meander bend).

Trotlines are set by anchoring one end near shore using the best manner possible (e.g., staked using a fence post or tied off on woody debris), stretching the line downstream at an approximate 45-degree angle to shore and anchoring the end using a suitable anchor (e.g., 10 lb. fluke or block anchor). Hooks will be baited with a piece of goldeye (*Hiodon alosoides*), cisco (*Coregonus artedi*), white sucker (*Catostomus commersoni*) or redhorse (*Moxostoma* spp.). Both fresh and frozen baits are acceptable. Complete the trap net and trotline set/lift form for each sample station (Appendix II). GPS coordinates for each individual trotline station will be recorded both on the set/lift data and in the GPS unit as a waypoint.

Each trotline will be fished for only one night; trotlines will not be reset in the same location. If a trotline is determined to be invalid for any reason, such as a tangled or broken line, data will not be taken from fish on that trotline. Fish will be released, the trotline repaired or replaced, and the trotline will be reset at that station location until a valid trotline set has been sampled. If the required number of trotline sets (18) within a site has been completed and less than 100 channel catfish greater than or equal to 20 inches TL (trotline and trap net combined) were not captured, supplemental trotlines can be set and fished at any location within the site until the minimum sample size is achieved. Data will be collected on all fish on the supplemental trotlines, however, only information from the original 18 sets will be used to construct and analyze channel catfish abundance indices (e.g., CPUE).

3. Minimum sampling requirements for each site:

a. <u>Reach 1, Site 1</u>
   i. Minimum of 30 trap net sets **<u>and</u>** a minimum of 100 channel catfish greater than or equal to 20 inches total length
b. <u>Reach 2, Site 1</u>
   i. Minimum of 30 trap net sets **<u>and</u>** a minimum of 100 channel catfish greater than or equal to 20 inches total length
c. <u>Reach 3, Site 1</u>
   i. Minimum of 30 trap net sets
   ii. Minimum of 18 trotline sets
   iii. Minimum of 100 channel catfish greater than or equal to 20 inches total length (trap net and trotline combined)
d. <u>Reach 4, Site 2</u>
   i. Minimum of 30 trap net sets
   ii. Minimum of 18 trotline sets
   iii. Minimum of 100 channel catfish greater than or equal to 20 inches total length (trap net and trotline combined)

4. Sample Station ID Coding

Sample station identification will be coded using an alpha-numeric system that accounts for gear type, stream reach, site location and individual station identification. Gear types are trap net (TN) and trotline (ATL). Reaches are the four predefined Reaches from Breckenridge to the Canada border (first digit). Site locations are the overall stream segment wherein the individual stations are located (second digit). Station identification is the number assigned to an individual trap net or trotline set within a sample site (last two digits). For example:

Station ID: TN1103 represents trap net station #3 within site 1 in Reach 1.
Station ID: ATL4217 represents trotline station #17 within site 2 in Reach 4.

This coding system will be used for existing and future sample locations associated with the Red River survey. Any new sample sites will receive a new, unique identification number. Existing site numbers, including those used in previous surveys will remain with the location on Red River. In other words, sample site numbers represent a distinct segment of Red River used for sampling, so if a new location on Red River is sampled that has NOT been included in a previously identified sample site, that location will receive a new sample site number.

E. Catch Data

Catch data will be recorded according to the most recent standard procedures outlined in the MN DNR Fisheries Stream Survey Manual using the fish sampling catch form (Appendix II). Identify and enumerate all fish captured during the survey. All individual game fish, including channel catfish, lake sturgeon, walleye, sauger and northern pike, will be measured (total length). Measuring all individuals from other species is encouraged; however, a subsample of 25-50 individuals from each panfish and non-game fish species per trap net can be measured if desired.

Individual weights of all game fishes are required for five measured fish from each 10 mm length group up to 300mm, and 10 fish from each 25 mm length group for fish over 300mm. Individual weights of additional game or non-game fishes are optional. Enumerate and batch weigh game and non-game fish by species that have not been individually measured and weighed.

In situations when the sample set has been determined to be invalid for any reason (e.g., a large hole in a trap net, the frame was collapsed, trotline was broken) the gear will be emptied and catch data will not be recorded. Notable information associated with invalid sample sets, such the presence of a rare, unusual or exotic species, should be documented.

F. Fish Aging

Aging will be done on all game fish species sampled. Channel catfish less than or equal to 449 mm (17.7 inches) TL will be aged during every survey. Channel catfish of all lengths will be aged every other survey beginning in 2015 (i.e., 2015, 2025, 2030, etc.).

Channel catfish will be aged using disarticulated pectoral spines, unless or until an alternative technique becomes available that results in more accurate information and/or is less invasive while maintaining adequate accuracy. Aging structure collection will follow methods outlined in the DNR stream survey manual (MN DNR special publication 165), which states, "Collect appropriate aging structures from at least five (preferably ten) fish from each 10 mm length group for fish <300mm. For fish >300 mm, collect structures from 10 or more fish from each 25 mm group." The Bony Part (Fraser-Lee) form can be used to track the collection of aging structures during a survey (Appendix II).

G. Species Other Than Channel Catfish

Timing of survey is probably not good for documenting the status of species other than catfish. However, it is important to document information on other species as well. Data pertaining to these species will continue to be collected according to standard stream survey procedures.
To date, electrofishing efforts have not proven effective in capturing either walleye or sauger. Therefore, summer electrofishing efforts will not be required as part of this survey. Efforts to identify an efficient and effective strategy for sampling walleye and sauger populations will continue. Fish community and biotic integrity information will be obtained through MPCA's large river sampling, which will be coordinated with this survey.

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Appendix II – Investigation of spatial patterning as a result of differing "Site" reach lengths

Introduction

As presently conducted, the Red River Channel Catfish survey sampling is conducted on four specific "Site" reaches, within four larger "Reach" divisions of the American reach of the Red River. This organizational structure is a holdover from pre-2010 surveys, when multiple Sites were sampled within each Reach. Each Site is subdivided into equal-distance segments, and targeted placement of gear occurs within the distance subunits. The goal is to maximize Channel Catfish catches.

Table A2.1. Red River Channel Catfish survey Site reach lengths.

Site	Reach Length (miles)
Reach 1, Site 1	2.18
Reach 2, Site 1	5.22
Reach 3, Site 1	4.05
Reach 4, Site 3	3.11

A historical artifact of the survey design is differing Site lengths. Functionally, this manifests itself as nets spaced either closer together or further apart, depending on the Site. Ricker (1975) referred to this potential problem as "competition by units of gear," whereby individual nets interfere or influence catches of adjacent nets. Simply, there is a potential for a lack of independence among samples, which is a foundational assumption of nearly all experimental designs and statistical methods. There is also the potential for inflated catches in some reaches, as the longer Site length allows for greater flexibility in targeted gear placement.

The purpose of this Appendix is screening for potential spatial autocorrelative data structuring, which refers to underlying process-driven spatial trends in data. This can be detected as clustering patterns in the catch data. Clustering can either bias overall Site CPUE high or low. If sample clustering is detected, corrective measures will be described in detail, and summarized in the Management Recommendations section of the attached report.

Methods

- The first approach was a global Moran's *i* analysis, conducted in ArcPRO, which established the existence of spatial autocorrelation and the bandwidth at which patterns occurred. Catch data was joined to each Site .lyr file of trap net location. Site-specific Channel Catfish catch was used as the predictor variable in all cases.
- Squared inverse distance weighting was used to conceptualize spatial relationships. This function is similar to the inverse distance method, except that the adjacency effect slope is sharper. Spatial influence drops off quickly, and only a target feature's closest neighbors will exert substantial influence

on computations for that feature. Thus, adjacent nets were assumed to have the strongest relationships computationally. Manhattan distance between features was used, so the between-net distance was measured by summing the absolute difference between the x- and y-coordinates. This approach deals with river meanders better than Euclidean ("as the crow flies") distance, which tend to cut off or across river bends. Row weight standardization was applied.

If spatial autocorrelative data structure was detected, a Getis-Ord General-*G* analysis was applied, also conducted in ArcPRO. This is used to measure the degree of high or low clustering, and can be thought as a *post-hoc* test such as a Tukey's HSD test following an ANOVA. Spatial conceptualization settings were consistent with the Moran's *i* analysis.

Results

No spatial autocorrelative structure was detected in the Channel Catfish catches, regardless of differing Site reach length net spacing (Table A2.2).

Table A2.2. Moran's *i* autocorrelation test results, examining interactive effects between nets resulting from differing reach lengths.

	Reach 1	Reach 2	Reach 3	Reach 4
Moran's *i*	-0.096	-0.157	-0.183	-0.127
p- value	0.808	0.530	0.399	0.729
z - score	-0.243	-0.628	-0.844	-0.347
Distance Threshold (miles)	0.110	0.248	0.195	0.746

Discussion

No gear interference was detected. In the 2022 survey and prior, the Channel Catfish relative abundance in the upstream reaches (1 and 2) was very high. This abundance may have minimized the probability of gear interference. Any given net did not intercept fish that otherwise could have been captured in a different net, as there were simply many available fish to sample. Inversely, trap nets do not sample Channel Catfish effectively in the downstream reaches (3 and 4). A lack of detections makes detection of spatial trends unlikely.

Nets exhibited no spatial clustering patterns, so independence of samples likely occurs. Frequentist and information-theoretic analyses can be conducted on these data with confidence that this underlying (*but rarely evaluated*) assumption is met.

Recommendations

- No corrective actions are necessary in survey design.
- Outdated Reach and Site nomenclature should be updated, as the stratified design has not been used since 2010; revise Appendix I - "Methods" accordingly.
    - For example, the "Reach 4, Site 3" description should simply be Reach 4.

Appendix III – Investigation of Channel Catfish measurement subsampling and standards for the Red River survey

Introduction

During the 2022 Red River Channel Catfish survey, it became apparent survey methods should be examined to ensure data quality standards were met. “When” and “to what extent” to subsample required quantitative examination to ensure high quality data, if subsampling was adopted.

Systematic subsampling for fish aging by length bin unavoidably slows field work, and is a standard practice to achieve high data quality. As the Red River Survey is conducted only once per five year period, localized high fish mortality is acceptable and anticipated while conducting fish aging workups. This examination is not concerned with fish aging methods, as these are generally well established by the MN DNR Lake Survey Manual.

The Lake Survey Manual (LSM) is referenced in preference to Stream Survey Manual, as the Red River is far larger in scale than the Stream Survey Manual anticipates in its guidance. We discuss how the statistical examination herein relates to standard DNR Lake Survey methods, as adopted for the Red River.

The purpose of this exercise was a specific examination of the data quality consequences of subsampling catches per site in the Red River Channel Catfish survey. Based on the results, a recommendation for survey methods is proposed.

Methods

Using Channel Catfish measured by crews in 2022 and 2015, two post-processing exercises were conducted to establish field methods that produced data with high strength of inference, while considering the request from field crews to potentially adopt subsampling methods.

Because PSDx values are a major outcome of the Red River Survey, statistical power to resolve changes in percentages was explored. In consultation with Dave Staples, DNR Fisheries Biometrician, a binomial power analysis was conducted. This constrains values between 0 – 1, which is analogous to PSDx values prior to whole integer conversion. The binomial margin of error was calculated for increasing sample sizes for a variety of statistical significance levels. The approach does not use “real” data, but simulates the interaction of varying sample sizes, statistical power, and significance values on the ability to detect changes in proportion. It is useful for exploration based on a comparison of curve asymptotes.

In theory and practice, additive field efforts will deliver diminishing returns of statistical confidence as an asymptotic quantity of “fish measured” is exceeded. Efforts, however, should not cease at the asymptotic quantity of fish as statistical confidence is still changing at this point. Any subsampling approach should ensure that a minimum number of fish are processed so, at various levels of statistical power, the slopes describing statistical confidence are effectively zero.

A bootstrap resampling exercise was also conducted based on the 2015 and 2022 Red River Channel Catfish catch data. The protocol was written to sample without replacement $n = x$ fish lengths from the catch data for 2,000 iterations and tabulate them, where n = 500, 1500, and 2000. An n = 3,000 was also attempted, but could not be completed due to resampling n exceeding base catch data n. From these length frequencies, analogous to measuring the n quantity of Channel Catfish 2,000 times from the catch data, PSD20, PSD24, and PSD28 values were calculated, tabulated, and used to create distribution curves of estimated PSDx values, per year, per n. The 95% confidence interval (CI) about the mean PSDx of each distribution were compared to the 95% CI calculated from the raw catch datasets for 2015 and 2022. The mean PSDx values from the resampling exercise were simply means of simulated data; as such, they are not presented. The associated 95% CIs, however, demonstrate the range of potential PSDx values expected based on increasing measurement effort.

Results

The binomial power analysis margins of error yielded asymptotic curves, with diminishing returns of statistical confidence as sample size increased (Figure A3.1). As expected, this generally demonstrated that the power to detect changes in a proportional value, such as PSDx, generally was greater at greater sample sizes. When statistical confidence was high (value ± 1%), a relatively low sample size was needed to effectively detect changes. When confidence was lower (value ± 12%), increases in sample size continued to reduce margin of error well after the asymptote. Slope of the lowest confidence curve became effectively zero, thus equivalent to the high confidence curve, at $n \geq 2{,}000$. As these are only modelling data, however, interpretation should be cautious. Rarely does ecological data have high or known statistical power, due to the wide array of environmental noise, measurement errors or directional biases present. Thus, while power analyses are useful, they tend to support the cautious ecologist’s view that sample size should be as large as practically possible, as this tends to reduce margin of error in estimates.

The bootstrap resampling, however, was based on 2 surveys’ fish measurement data. The resampling generated frequency distributions of potential PSD and PSDx values based on 2,000 iterations. The 95% CI widths about the frequency mean value were compared to the “true” 95% CI width, as represented by those calculated from the “total” fish measurements in the 2015 and 2022 data (Table A3.1). While PSDx and associated CI are conventionally rounded to the nearest whole integers, a decimal was acceptable here for the sake of comparisons.

The 2015 raw catch data included larger percentages of longer length-class fish, compared to the 2022 data. This difference was advantageous for modelling, as it allowed for direct observation of impacts of sample size on resolution of higher versus lower PSDx values.

The greater PSD20 95% CI width was associated with the higher availability of potential subsample variance. Simply, if the PSDx numerator length cutoff was lower, a larger candidate pool of fish were available above the cutoff in the size distribution for potential sampling. The subsample has a greater random chance of overshooting high or low as a wider size range of fish are available. This is why the 95% CIs are wider for PSDx length categories that include shorter fish.

Table A3.1 demonstrates the value of measuring more fish, when a fishery's management is targeted toward a clear understanding of trophy size structure. The 2015 PSD20 value was 23 ± 3 (95% CI). Thus, we expect if the population was sampled 100 times, in 95 of those instances, PSD20 would range 20 – 26. Retaining the decimal, the 95% CI width was 2.7. If only 500 fish were measured, estimate uncertainty effectively doubled to 5.6. When 1500 fish were measured, CI width (2.4) approached the "true" with of 2.7. This was more notable when catches of large fish were rarer in 2022; the PSD28 "true" confidence interval was 0.5, and it took 2000 fish to yield a similar interval. As predicted by the power analysis and common understanding, CI width contracted as more fish were measured.

Discussion

The need for adherence to a uniform set of field methods was demonstrated in 2022. Based on differing approaches between field crews working in Reaches 1 and 2, the time investment to measure all fish is approximately 2-3 hours of additional field work. Time investment in fish measuring was not excessive when all fish were processed, and crews returned prior to the close of business with ample time to prepare for the following day. This included travel time. While Lake Survey Manual (LSM) does allow for subsampling "when measuring [all fish] is impossible in the time available," this was demonstrably not applicable. Area staff time investment on this Regional survey must be measured against the 5-year survey interval, thereby justifying additional field effort where it occurs.

First, we need to address a notion that "large hauls" are commonplace in the Red River survey, necessitating fish measurement subsampling. As shown in Table A3.2, the majority of net hauls contain less than 100 Channel Catfish. In fact, the nearly the same number of nets contain less than 200 Channel Catfish. There are reasonably few "large haul" nets that would require some form of subsampling, specifically addressing crew concerns of excessive time investment or fish mortality. Most nets simply do not contain enough fish to justify fish measurement subsampling.

Reducing the quantity of fish measurement, as demonstrated herein, increases uncertainty in PSDx metrics. In the arbitrary example afforded by crew decisions in 2022, PSDx values calculated using nets from Crew 1 versus Crew 2 differed by ~50%. Increasing statistical confidence requires more fish measurement, and this is more readily observed when statistical power is low. When statistical power is unknown, a precautionary approach should assume lower power.

No maximum values for fish measurement per site are listed *per-se* in the LSM or Stream Survey Manual; however, the 50 panfish measurement exception per-panel, per-gill net effectively sets a 250 fish threshold for a given site. Note this is site-specific, and has no bearing on successive sites in a survey. When panfish catches are pooled for length frequency determination, the cumulative length distribution makes a number of assumptions, one being enough individuals to be representative of the "true" panfish length frequency. It also assumes standard methods, standard quantities, and standard subsampling approaches, if data are to be comparable to other surveys or survey components. Trap nets have similar 50 panfish recommendations per site. The LSM subsampling section discusses a 25 – 50 fish per-species, per-site/gill net panel approach, but goes on to highlight multiple problems associated with subsampling.

We can use the 2022 catch data, the year with the largest CPUE and total catch on record, to examine practical effects for field crews of adopting a subsampling approach. The modelling results shown above can inform Reach-specific targets for total number of measured fish, as this is the scale at which PSDx is calculated. In years with low catches of larger length-classes (e.g. 2022), modelling shows 2000 fish should be measured to achieve the desired PSDx data quality. In years with higher catches of larger length-classes (e.g. 2015), this approach would yield greater precision of estimates, thus meaning no net-negative would result from this approach. Either a “first 150” or “first 200” per net Channel Catfish measurement approach would achieve this goal, based on the 2022 survey. In a year resembling 2015, nearly all fish would be measured.

Recommendations

- The Red River survey may adopt either a “First 150” or “First 200” Channel Catfish measurement approach per net location; revise Appendix I - “Methods” accordingly.
    - As shown here, adoption of either subsampling approach will not have undue negative impacts on PSDx data quality.
    - The tablet survey module makes tracking quantity of measured fish easy for crews.
    - This subsampling approach stipulates fewer fish measurements than the LSM gill net *de facto* subsampling threshold quantity for panfish, which reflects the reality of that gears’ usual catches.
    - If adopted, this accommodation is not subject to individual interpretation. Standard method adherence will be emphasized by Area Supervisors prior to the next Red River Survey.

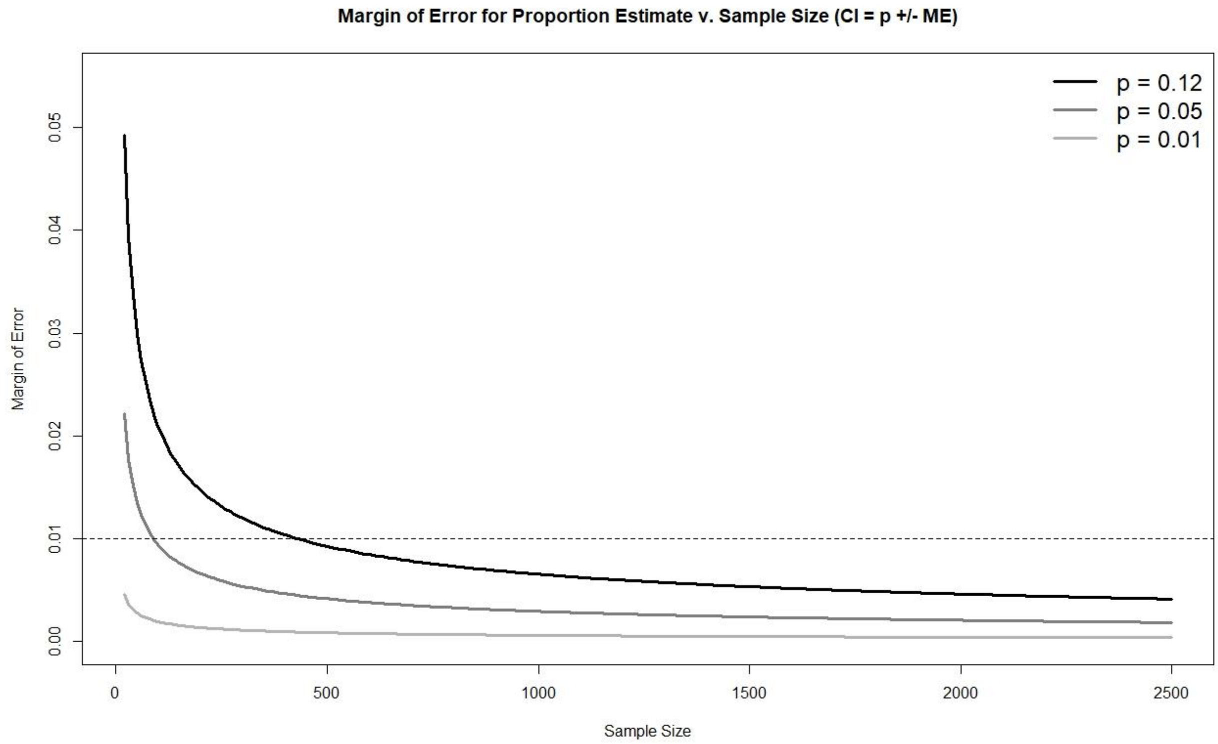

Figure A3.1. Binomial power analysis changes in margins of error relative to sample size, calculated for common statistical significance levels (*p*-values).

Table A3.1. Full dataset and bootstrapped 95% confidence interval widths for PSDx values, 2015 and 2020 Channel Catfish length frequencies.

		Full Data CI width	n = 500 CI width	n = 1500 CI width	n = 2000 CI width
2015	PSD20	2.7	5.6	2.4	1.4
	PSD24	1.8	3.8	1.4	1.0
	PSD28	1.3	2.4	1.1	0.7
2022	PSD20	1.1	3.4	1.7	1.4
	PSD24	0.8	2.4	1.2	1.0
	PSD28	0.5	1.2	0.7	0.5

Table A3.2. By Reach and year, the number of nets by Channel Catfish catch thresholds. Also by Reach and year, tallies of Channel Catfish caught, measured, and sum of measured individuals under potential field method rules. In each Reach in 2022, 30 nets were fished per the standard survey methods. Extra nets were fished in 2015 (Reach 1 = 32, Reach 2 = 40) due to low catches; these are included here for additional insight into routine Red River Channel Catfish total catches.

		2022		2015	
		Reach 1	Reach 2	Reach 1	Reach 2
Nets by Contents	< 100 CCF	17	22	28	39
	< 150 CCF	17	22	29	39
	< 200	19	22	31	40
Channel Catfish Tallies	Caught	4366	2866	1254	714
	Measured	2576	2266	1254	714
	"First 100"	1559	1599	966	634
	"First 150"	2109	1949	1142	684
	"First 200"	2620	2118	1244	714