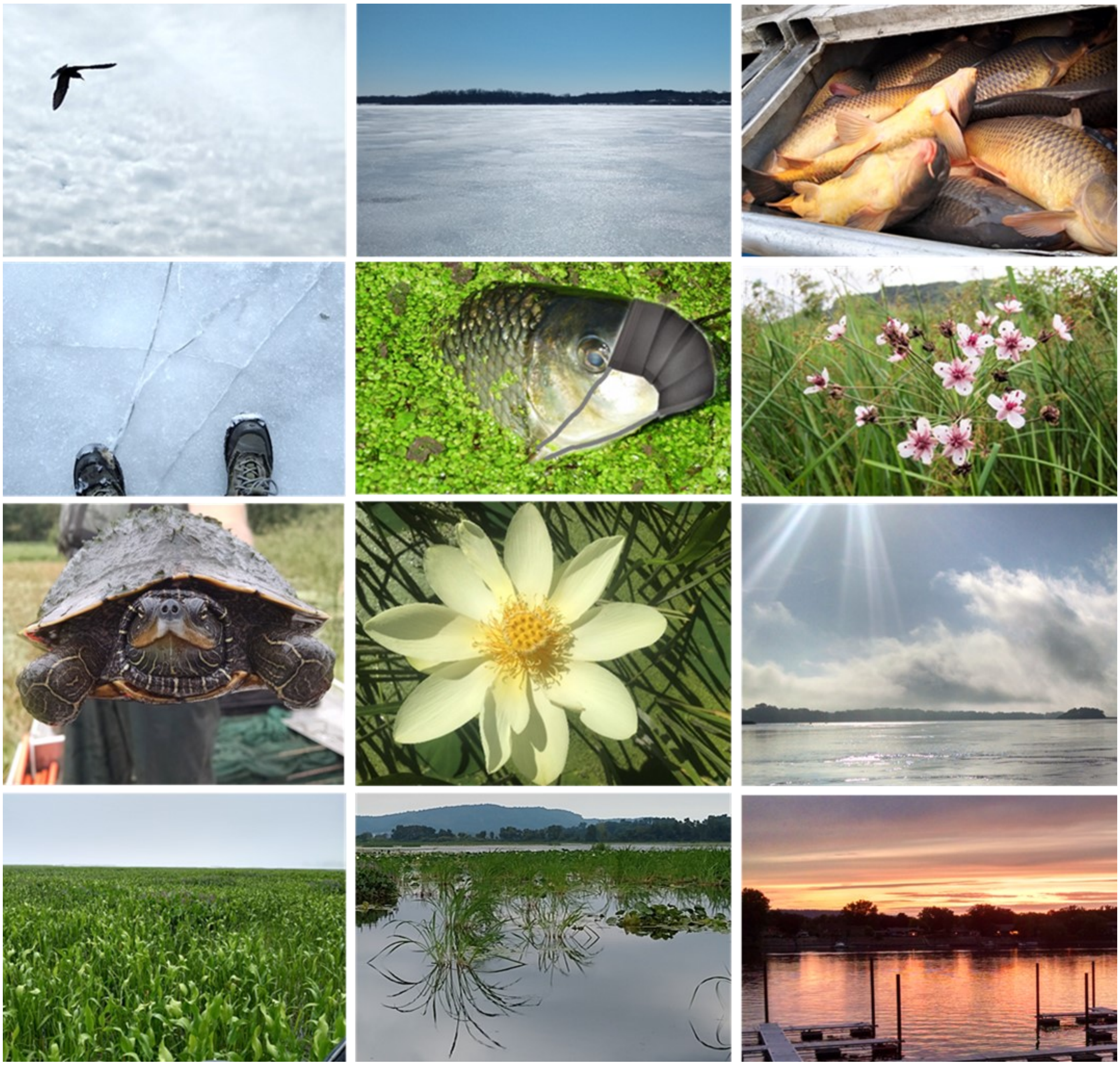
Upper Mississippi River Pool 8 Long-Term Resource Monitoring Year 2020 Status Report

Wisconsin DNR Office of Great Waters, Mississippi Field Station 2

EGAD #3200-2021-18



About this Report

Purpose

This status report describes the results of monitoring in 2020 by the WI DNR as a partner in the US Army Corps of Engineers (USACE) Upper Mississippi River Restoration Program Long-Term Resource Monitoring element. The restoration program's monitoring element is conducted by the U.S. Geological Survey Upper Midwest Environment Sciences Center (UMESC) in cooperation with the five Upper Mississippi River System states (Illinois, Iowa, Minnesota, Missouri, and Wisconsin). The USACE provides guidance and overall program responsibility.

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Andrew Bartels – Co-Author and Fisheries Specialist, Wisconsin DNR
Alicia Carhart - Co-Author and Vegetation Specialist, Wisconsin DNR
Deanne Drake - Co-Author and Mississippi River Science Lead, Wisconsin DNR
John Kalas - Co-Author and Water Quality Specialist, Wisconsin DNR
Kraig Hoff – Document Reviewer and Field Operations Specialist, Wisconsin DNR
James Fischer – Document Reviewer and Mississippi River Team Leader, Wisconsin DNR
Paxton Smith – Document Reviewer and Vegetation Technician, Wisconsin DNR
Lisa Kosmond Helmuth – Document Formatting, Water Quality Plan Program Coordinator, Wisconsin DNR

For More Information

LTRM website: Long Term Resource Monitoring - Environmental Management Program (LTRM-EMP) (usgs.gov)
UMRR website: Upper Mississippi River Restoration (UMRR) Program (army.mil)
WDNR Documents Online: https://dnr.wi.gov/water/egadSearch.aspx

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Cover

Photos used in this collage are used courtesy of the Wisconsin Department of Natural Resources.

Black Tern at Blue Lake	Target Lake in winter	Common Carp in a commercial fishery
Thin Ice	COVID19 protocols	Flowering rush invasion of 2020
False Map Turtle (2017)	American lotus	Sunbeams on the Main Channel
New *Sagittaria* expanse	Still day at Reno	Sunset on the Black River

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Wisconsin Department of Natural Resources
101 S. Webster Street • PO Box 7921 •
Madison, Wisconsin 53707-7921 608-266-2621

WISCONSIN DEPT. OF NATURAL RESOURCES

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Executive Summary

This report summarizes the annual increment of monitoring accomplished in 2020 by the Wisconsin Department of Natural Resources' La Crosse Field Station for the Long-Term Resource Monitoring Element of the Upper Mississippi River Restoration Program. This document provides data, observations, and analyses of Navigation Pool 8 of the Mississippi River, emphasizing 2020 sampling year in the context of historic data and trends.

In 2020, COVID-19 restrictions on field operations imposed by the Wisconsin Department of Natural Resources prevented collection of 1) water quality fixed site sampling (FSS) data in April and May, 2) spring water quality stratified random sampling (SRS) data, 3) fisheries day electrofishing data and 4) fisheries tailwater trawl data. Aquatic vegetation monitoring was delayed by one week but was otherwise unaffected.

Discharge in Pool 8 was higher than average until early May 2020, but similar to long-term averages for the rest of the year. This marked a substantial change from the persistent high-water conditions that characterized the growing seasons of the last decade and extreme high water through most of 2019.

Quarterly water quality monitoring in 2020 [winter (January), summer (July-August) and fall (October)] indicated relatively cool water temperatures, clear water and low nutrient concentrations, particularly in fall. Although winter water temperatures were about average (<1°C), summer and fall water temperatures were several degrees cooler than long-term median values. Total suspended solids concentrations were near the long-term median values in winter and summer, but very low (at or below the 10th percentile of seasonal values between 1993-2020) in fall. They were also generally consistent with a long-term trend of increasing water clarity in Pool 8. Chlorophyll a concentrations were similar to long-term median values in winter and summer and also very low in fall. Total phosphorous concentrations were very low in all three quarters. Total nitrogen concentrations were slightly higher than long-term median values in winter and fall and very low in summer. Median dissolved oxygen concentrations were similar to long-term values in summer and fall and were near ~100% saturation. During the three-week winter sampling period in January 2020 median ice thickness was approximately 21 cm compared to long-term median of ~28 cm, and median snow depth was only ~1 cm, compared to the long-term median of 5 cm. Although thin snow and ice cover can contribute to high rates of winter photosynthesis and oxygen production, winter dissolved oxygen concentrations in 2020 were under the 10th percentile of long-term median values. Few instances of hypoxia were documented, however, and the median winter dissolved oxygen value still exceeded the 5 mg/L minimum guideline for biota.

Pool-wide detection rates (prevalence) of submersed aquatic vegetation remained similar to generally high levels documented since the mid-2000s. A number of changes in the prevalence of other life forms, however, were evident and were likely associated with the transition from sustained high water to near-normal growing season discharge conditions and shallower water in 2020. Rooted-floating leaf species prevalence had decreased substantially between 2016 and 2019 yet rebounded from ~25% in 2019 to ~36% in 2020. Particularly high abundance and vigor of American lotus (*Nelumbo lutea*) was noted in 2020 by the field crew but were reflected in monitoring data as only small increases in prevalence and cover values. Additionally, dense beds of arrowheads (*Sagittaria rigida and S. latifolia*) were observed in many areas where they had been absent in recent high-water years, suggesting a robust seedbank that responded to lower discharge of 2020. The observed flourishing of arrowheads was reflected in a marginal increase cover but not in prevalence in the monitoring data. The overall prevalence of emergent lifeforms (all emergent species combined) decreased between 2019 and 2020 due to a sharp decline in wild rice (*Zizania aquatica*) which was detected at 28% of sites in 2019 and only 10% of sites in 2020.

Invasive flowering rush (*Butomus umbellatus*) made an alarming, sudden, and widespread appearance in the Upper Mississippi River in 2020. Many thousands of flowering plants were observed in the lower half of Pool 8 and similar observations were reported in LTRM Pools 4 and 13. Prior to 2020 in Pool 8, only a single, known individual plant had been detected by LTRM or any other agency. Genetic analyses coordinated by partners at US Fish and Wildlife showed that the triploid form of *B. umbellatus* is invading the Upper Mississippi River, and spread occurs through root fragmentation mediated by muskrat, boat (especially mud) motors or other sediment disturbances.

Fish monitoring effort was substantially reduced in 2020 with no day electrofishing or tailwater trawling. Hoop and fyke net sampling were conducted as usual. Although analyses with the resulting data set were limited, no major change from recent years was indicated. Fish community diversity in 2020 was not estimated due to the lack of electrofishing data. Most common fish species were detected and were present in similar proportions to recent years. As usual, several rare species were recorded. One Wisconsin-listed threatened species (River Redhorse) and several species of special concern (Weed Shiners, Mud Darters, and Pugnose Minnow) were captured in the 2020 monitoring. No new invasive species were detected and Common Carp abundance was similar to recent years. Weed Shiners, Bluegills, and Spotfin Shiners dominated catch in terms of numbers, while Bowfin, Channel Catfish and Common Carp dominated catch in terms of biomass. Asian Carp (Bighead, Silver, or Black) have never been detected in LTRM sampling over the period of record (1993 – 2020). In most cases, catch of recreational species was not comparable to previous years due to reduced sampling effort in 2020. Nevertheless, the available data indicated no major changes.

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Climate and Hydrograph 2020

Methods

Climate data were acquired from the National Weather Service's website for La Crosse, Wisconsin (source: National Weather Service, http://www.weather.gov/arx/lse2020). Herein, we report simple summaries of local temperature and precipitation patterns for the year.

Pre-1988 discharge data were previously obtained from the U.S. Army Corps of Engineers' (Corps) web site for water information on the Mississippi River, which is no longer available. For 1988-2018, we requested a dataset of daily discharge data directly from St. Paul district Corps water personnel. For 2020, data were obtained at the Corps Access to Water website.

Herein, we used discharge estimates from Lock and Dam 8 at Genoa, WI, as they reflect important local tributary flow inputs. We report daily discharge values, using values recorded at 0800 hrs from 1959-1987, and calculated mean daily values for multiple daily observations reported in recent years. All discharge data reported are in cubic feet per second (cfs). Data missing for 12 dates in 2020 were interpolated from those dates adjacent to the gaps.

A historical hydrograph was constructed by computing the mean daily discharge values from the years 1959-2019. The daily discharge for 2020 was then overlain on the long-term daily mean to observe departure from typical conditions (Figure 1.1 top). Additional analyses examined annual, growing season (May through September), and spring flood discharge characteristics. Mean annual discharge was calculated from daily values, plotted for years 1993-2020 (i.e. LTRM period of record for stratified random sampling), and overlain on a plot containing the historic mean, 10th, and 90th percentiles for all years (1959 to 2020; Figure 1.1 middle). Mean growing season discharge was calculated and plotted similarly to the mean annual discharge (Figure 1.1 bottom). The spring flood pulse was characterized according to timing, duration, and magnitude. The timing of the spring flood was ascribed to the month (March, April, or May) containing the preponderance of dates on which the ten highest discharge values were observed each spring. Duration of the spring flood was characterized by the number of days each spring in which the discharge exceeded the historic 75th percentile discharge value from March through May. Magnitude was reported as the maximum spring discharge value for each year (Table 1.1).

Results

La Crosse area climate in 2020 was warmer (+2.3° F above mean annual air temperature) and a little drier (-2.24" below mean annual precipitation) than normal. The only month that was much cooler than normal was October (-4.2° F), whereas January (+6.6° F), March (+5.5° F), November (+5.9° F), and December (+6.0° F) were much warmer than usual. June, July, and August were all slightly warmer than usual. Snowfall for the winter months of 2020 was slightly higher than average in January and February with nearly 24" falling, but only about half of average in March and April with less than 4" falling. More precipitation fell as rain than snow when compared to long-term averages in March and April. June was the only month in 2020 where precipitation was much above normal (+2.97"). Precipitation was below normal in April (-1.71"), July (-2.54"), and December (-1.00").

Compared to recent years of very high water, the 2020 hydrograph (Figure 1.1, top) more closely resembled the historic averages, in part due to snowpack and precipitation conditions in the upper watershed and to relatively normal local amounts of precipitation. Still, discharge was above the long-term average from the beginning of the year through the latter part of April. During that four-month span, the April spring flood was evident as a significant, if short-lived, event. Several minor spikes in discharge occurred from June through September, likely attributable to local rainfall events. These small spikes in discharge likely prevented flow from falling below the long-term average for all but a couple of short periods in May, June, and October. Thus, the first four months of 2020 saw high water, but the system transitioned to relatively normal discharge amounts and patterns beginning in May.

Despite the relatively normal discharge between May and December of 2020, mean annual discharge (Figure 1.1, middle) was among the top ten values for the LTRM era, and approached the 90th percentile for the period. Much of this effect was likely due to residual high flow from 2019 in the first few months of the year and a substantial spring flood. This was the fifth consecutive year of flows near or above the 90th percentile, and eighth out of the past eleven, standing in stark contrast to the previous era, where eight of ten years experienced below normal discharge.

The growing season (May-September) mean daily discharge (Figure 1.1, bottom) was close to the long-term average, providing biota a welcome respite from recent high-water summers. Of note, however, is that many forest stands within the floodplain have succumbed to prolonged flooding and are now dead. Despite relatively normal flows from May onward, 2020 was the 11th consecutive year of normal or above average summer flows. The last time an extended low water growing season occurred was 2009.

The spring flood occurred slightly earlier in 2020 than the historic peak flow (Figure 1.1, top), but still happened during April (Table 1.1). This was the second consecutive year to exhibit typical spring flood timing, after a 7-year period of either early or late spring floods. This may benefit fauna that are adapted to spring spawning or nesting, as well as plants that germinate early in spring. Water levels during the spring were elevated for about half of the three-month period, and the peak discharge of 132,338 cfs represented a medium-sized event (Table 1.1).

Figure 1.1. Year 2020 hydrograph at Lock and Dam 8

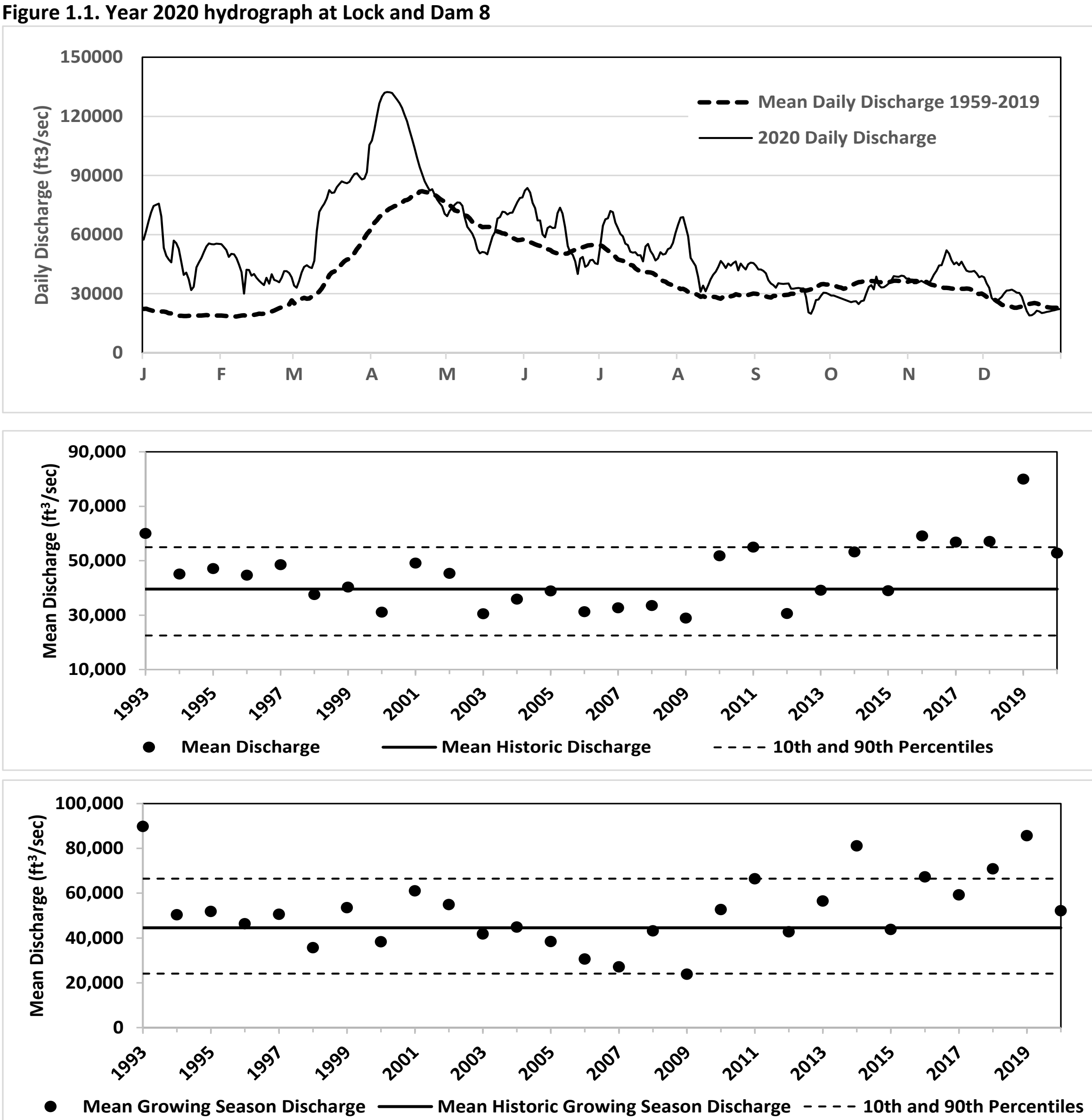


Figure 1.1. Top panel - Daily discharge at Lock and Dam 8 on the Upper Mississippi River for 2020 is represented by the solid line. Mean daily discharge by day of the year for 1959-2019 is represented by the dotted line. Middle panel - Mean discharge by year is represented by the black dots. The solid line represents mean historic discharge for 1959-2020. The dashed lines represent the 10th and 90th percentiles for 1959-2020 discharge. Bottom panel - Mean growing season discharge (May-Sept.) by year is represented by the black dots. The solid line represents mean historic growing season discharge for 1959-2020. The dashed lines represent the 10th and 90th percentiles for 1959-2020 growing seasons.

Table 1.1 (below) Spring flood pulse statistics by year during the LTRMP period of record (1993-2020) for discharge at Lock and Dam 8 of the Upper Mississippi River. Duration represents the number of days each spring when discharge was above the 75th percentile from the long-term record (1959-2020). Timing represents the month when the preponderance of the ten highest discharge days were observed each spring. Magnitude represents the maximum discharge observed each spring.

Table 1.1 Spring flood pulse statistics by year during the LTRMP period of record (1993-2020)

Year	Duration	Timing	Magnitude
1993	56	April	116200
1994	20	May	107100
1995	27	May	86000
1996	29	April	140200
1997	40	April	188300
1998	22	April	122500
1999	32	May	110400
2000	0	March	66500
2001	54	April	225100
2002	18	April	121100
2003	23	May	116900
2004	3	April	80300
2005	19	April	96300
2006	24	April	104000
2007	18	April	87400
2008	40	May	101000
2009	11	April	83300
2010	26	March	114100
2011	67	April	168800
2012	0	May	76200
2013	50	May	116900
2014	49	May	133500
2015	1	May	79600
2016	14	March	106200
2017	50	May	129200
2018	25	May	135100
2019	77	April	175404
2020	43	April	132338

Water Quality

Methods

The focus of the LTRM water-quality component is to collect limnological information relevant to the suitability of aquatic habitat for biota and transport of materials within the system. Since 1993, the LTRM water-quality sampling design has incorporated year-round fixed-site sampling (FSS) and quarterly stratified random sampling (SRS). This combined sampling approach provides information at both broad spatial scales, with low temporal resolution (i.e., SRS quarterly), and at small spatial scales, with higher temporal resolution (i.e., FSS bi-monthly April-August and monthly September to March). SRS tracks conditions at spatial scales corresponding to sampling strata or larger (i.e., pool-wide or sampling reach) and at seasonal to annual time scales or longer. In contrast, FSS provides information at more frequent intervals (i.e., within season), at specific points of interest such as tributaries, tailwaters, impounded and backwaters with high habitat value. The data used for this report are weighted pool-wide median values from Pool 8 SRS sampling. Water temperature and dissolved oxygen (DO) concentrations used in this report were surface measurements taken at 0.20m depth. Water samples were collected near the surface (0.20m depth) to quantify total suspended solids (TSS), chlorophyll a, total phosphorus (TP) and total nitrogen (TN). More details on LTRM water quality sampling methods can be found in Soballe and Fischer (2004) at: http://www.umesc.usgs.gov/documents/reports/2004/04t00201.pdf. More in-depth graphical display of data and summary data pertaining to water quality metrics by season, reach and sampling stratum can be found by utilizing the LTRM Water Quality Graphical Data Browser at:
http://www.umesc.usgs.gov/data_library/water_quality/water_quality_page.html.

Results

Temperature

Pool 8 water temperatures in 2020 were near the long-term median for winter, but well below for summer and fall (below the 25th and 10th percentile respectively, Figure 2.1A). Median temperature for fall was 9.06°C, and only 2009 had a median fall temperature that was lower at 8.91°C. Water temperature can have direct and indirect effects on large river ecology. Warm water temperatures can result in higher respiration rates, leading to lower oxygen saturation concentrations, which can increase the frequency of hypoxic conditions (Houser et al., 2015; Likens 2010). Water temperature also influences the rate of photosynthetic production in aquatic ecosystems (with lower rates of photosynthetic productivity at very low and high water temperatures, and higher rates of productivity at intermediate temperatures).

Figure 2.2A-F Box plots represent the 10th, 25th, 50th, 75th, and 90th percentiles of the medians by stratified random sampling season

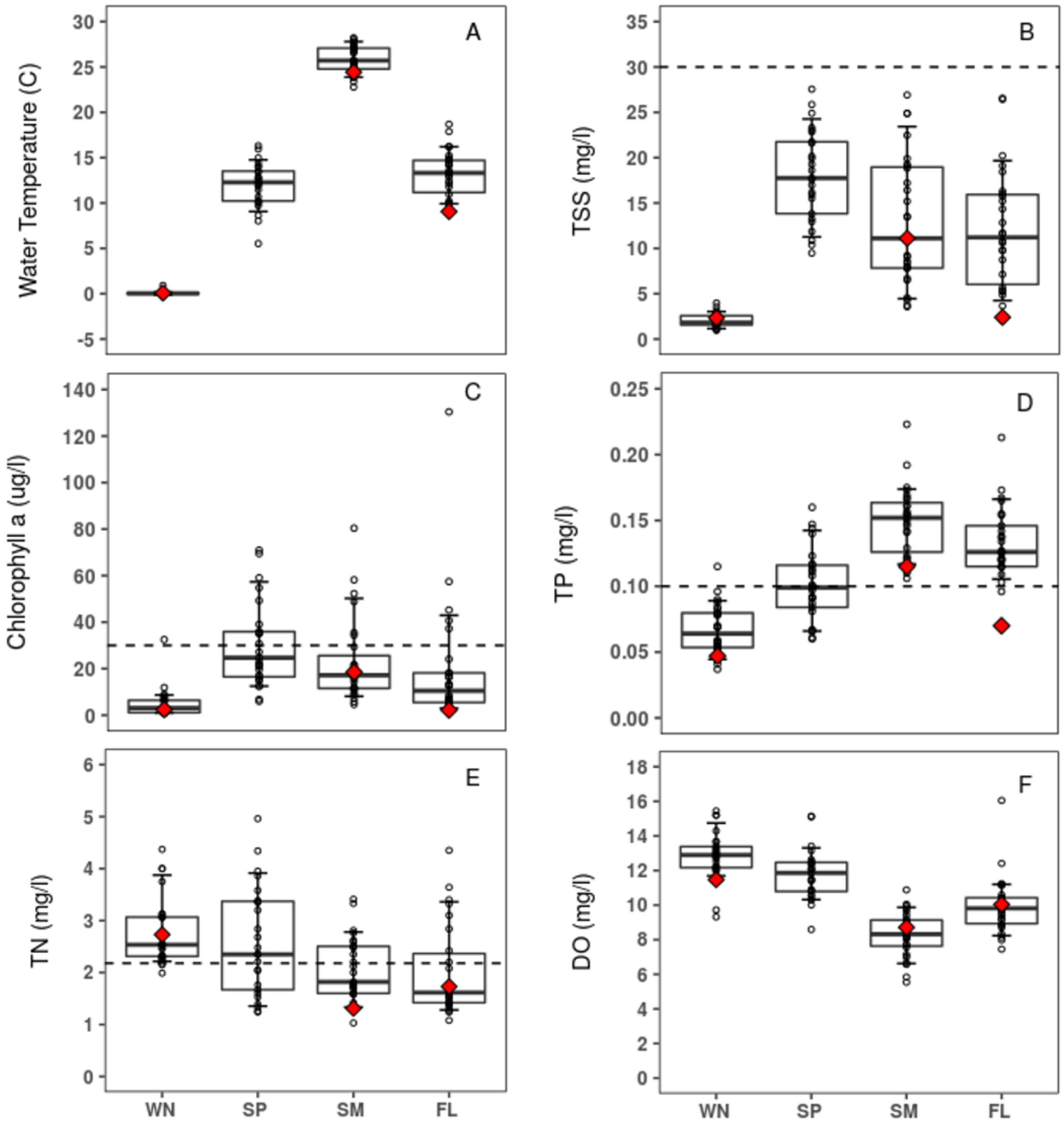


Figure 2.2A-F Box plots represent the 10th, 25th, 50th, 75th, and 90th percentiles of the medians by stratified random sampling season for the Long-Term Resource Monitoring period of record (1993-2020). The diamonds represent the weighted pool-wide median for each parameter by season for 2020. The dashed line represents: (B) the upper limit to sustain submersed aquatic vegetation in the Upper Mississippi River from Giblin et al., 2010; (C) the lower limit of the eutrophic range as defined by Dodds et al. 1998; (D) the total phosphorus criterion for non-wadeable rivers in Wisconsin as defined by NR 102.06; (E) the upper limit of the range suggested for TN as defined by the USEPA, 2000. Sampling was not conducted during spring 2020 due to Covid-19 restrictions on field work.

The LTRM SRS data (trends are available using the LTRM data browser linked above) do not show any strong trends in pool-scale median temperature over the period of record (1993-2020). A weak increasing trend is seen in winter, weak decreasing trends are seen in spring and fall (Figure 2.2), and no trend is seen in the summer data. While the median pool-wide water temperature for fall was 9.06°C, the median temperature for main channel and backwaters was 12.70°C and 8.10°C respectively. This difference is because water temperatures can fluctuate relatively rapidly with changing local air temperatures in the typically shallow (<1.5m) backwaters and impounded areas due to larger surface area-to-volume ratios and longer water residence times than deep main channel areas. Backwaters and impounded areas make up ~60% of the Pool 8 sampling area and a larger percentage of the SRS sites, and therefore have a greater influence on the pool wide median temperature. It's unsurprising that fall water temperatures were cool given the cool air temperatures (especially at night) that we experienced during Fall 2020. While Fall of 2020 was an anomalous year in terms of cooler water temperatures, the long-term decreasing trend (albeit weak) during fall (Figure 2.2) is surprising, considering an average increase in fall air temperature of approximately 5°F observed in Wisconsin between 1950-2018 (https://wicci.wisc.edu/wisconsin-climate-trends-and-projections/).

Figure 2.2 Temperature Pool 8, Pool Wide (Fall)

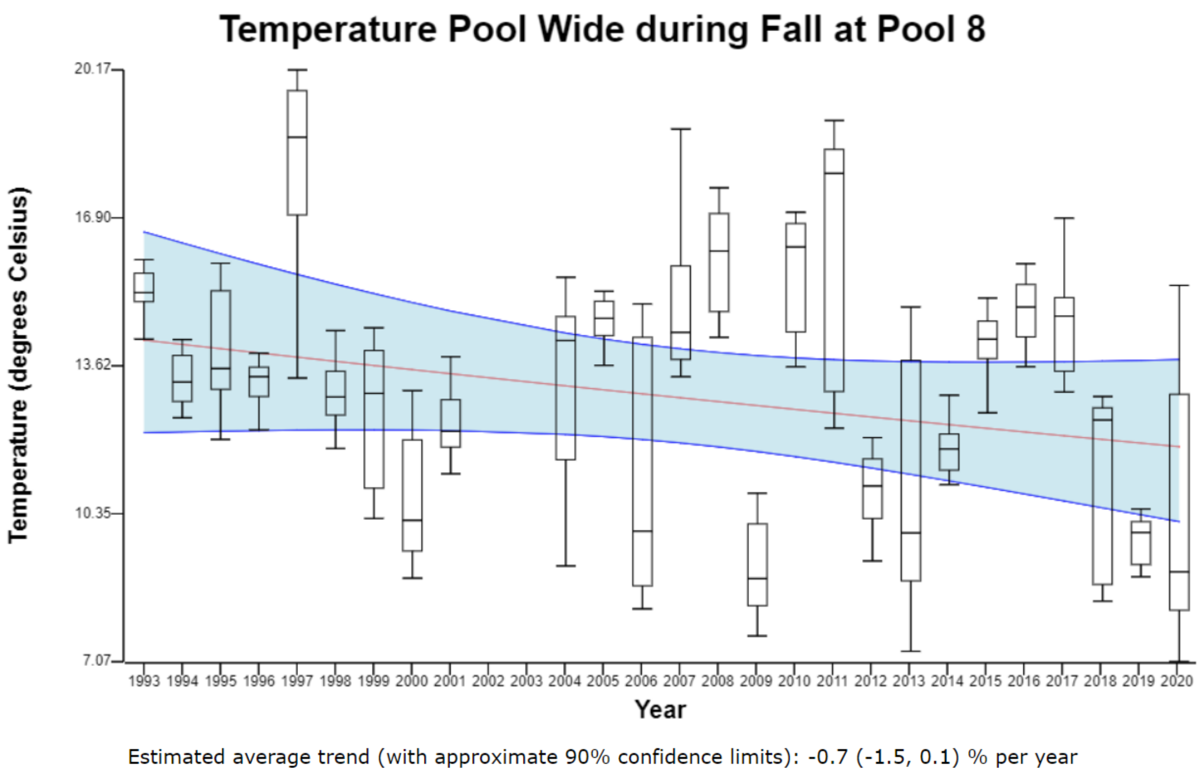


Figure 2.2. A weak negative trend in fall water temperature is suggested by the long-term monitoring data with the second-lowest median value occurring in fall 2020. This figure was produced by the LTRM graphical browser at: http://www.umesc.usgs.gov/data_library/water_quality/water_quality_page.html.

Constituents

Total suspended solids (TSS) concentrations were near the long-term median values in winter and summer, and below the 10th percentile in fall (Figure 2.1B). Fall 2020 had one of the lowest median TSS values (2.4 mg/l) regardless of season over the LTRM period of record (1993-2020). The LTRM SRS Pool 8 data trend data (available using the LTRM data browser linked above) show a strong decreasing trend in pool-wide TSS for spring, summer and fall, and a weak decreasing trend for winter. Pool-wide median TSS concentrations have rarely exceeded the criteria recommended to sustain submersed aquatic vegetation in the Upper Mississippi River during all seasons (<25 mg/L UMRCC 2003, or <30 mg/L Giblin et al., 2010).

Chlorophyll a concentrations in 2020 were near the long-term median for winter and summer, and near the 10th percentile in fall (Figure2.1C). The LTRM SRS trend data (available using the LTRM data browser linked above) show a weak decreasing trend in winter and spring, and moderate decreasing trends in summer and fall. Median chlorophyll a concentrations during 2020 were well below the eutrophic range for rivers (>30 µg/L, Dodds et al., 1998).

Total phosphorous (TP) concentrations in 2020 were near or below the 10th percentile for winter, summer and fall (Figure 2.2D). The LTRM SRS data (pool-wide medians 1993-2020) show a weak decreasing trend in TP for spring, a fairly strong decreasing trend in winter and fall and a moderate decreasing trend in summer. The Wisconsin criterion for TP impairment of non-wadeable rivers is when summer average TP (from six samples taken monthly from May to October) exceeds 0.10

mg/L (WDNR 2020). While the SRS sampling doesn't allow direct comparison, TP concentrations were above the 0.10 mg/L during summer and below during fall.

Total nitrogen (TN) concentrations in 2020 were just above the long-term median in winter and fall, and near the 10^{th} percentile in summer (Figure 2.2E). In 2020, TN exceeded the maximum concentration of 2.18 mg/L recommended by the USEPA for ecosystem health (USEPA, 2000). The EPA minimum criterion is 0.6 mg/L, which was always exceeded. Trends for TN are mixed, the LTRM SRS data (pool-wide medians 1993-2020) show a strong increasing trend in winter, a weak decreasing trend in spring and summer, and a weak increasing trend in fall.

Constituents – mechanisms and synthesis

Important indicators of water quality suggest substantial improvement over the period of LTRM monitoring in Pool 8. This includes long-term increase in water clarity, long-term decrease in TP in all seasons, and long-term decrease in summer TN and NO_3-N, and neutral or slightly decreasing trends in Chlorophyll a in all seasons. The exception to the favorable or neutral trends is winter TN and NO_3-N, which have increased steadily over the LTRM period of record. Observations in 2020 were generally consistent with the long-term trends. The improvements are likely due to a combination of factors, potentially including best management practices implemented in the watershed over past decades and Habitat Rehabilitation and Enhancement Projects (HREPs) implemented by the Upper Mississippi River Restoration. HREPs in Pool 8 have helped to reduce wind fetch and current velocity in key areas of Pool 8, ultimately reducing the amount of erosion and wind resuspension of sediments and allowing aquatic vegetation to establish in large areas. Through positive feedbacks, aquatic vegetation, which has also increased substantially over the period of record in Pool 8 (see Chapter 3), creates additional areas suitable for its establishment by trapping TSS, attenuating waves, reducing water velocity, erosion and wind resuspension.

The extremely low TSS observed in fall 2020 was likely linked to the extremely low TP. Heavy rain events can cause increased erosion/runoff in the watershed and, therefore, increased sediment delivery to the river. A significant fraction of Upper Mississippi River TP input is adsorbed to the TSS load; hence the concentration of TP tends to covary with TSS.

Significant phosphorous inputs can also arise from sediment microbial activity, especially in backwaters experiencing anoxic conditions in warmer months. This is referred to as anoxic sediment release of phosphorous. Above average discharge (during summer SRS), and, therefore, more water exchange between the well oxygenated channel water and backwater areas, may have limited anoxic conditions and reduced the rate of anoxic sediment release of phosphorous. During summer, hypoxic conditions (DO <3mg/l) were observed at only 7 of 150 sites and only 2 out of these 7 sites were anoxic (DO = 0 mg/l).

Chlorophyll a is an indicator of phytoplankton biomass in the water column. Light, temperature, nutrients and hydraulic retention time are the primary factors determining phytoplankton biomass and growth in the UMR, as in lakes (Houser et al. 2015; Likens 2010, Soballe and Kimmel 1987). While nutrient availability likely doesn't limit phytoplankton production in Pool 8, the frequent and erratic spikes in discharge commonly observed in Pool 8 may explain the relatively low chlorophyll a concentrations due to the effects of dilution, mixing, flushing and decreased retention time. Thus, chlorophyll a concentration may not be a good indicator of eutrophication in Pool 8. However, 2020 had some of the lowest median TP observations in the LTRM period of record and TN was also relatively low in summer; this may be a sign of progress in nutrient reduction efforts being implemented in the watershed. Despite efforts to reduce nitrate-nitrogen delivery to groundwater, rivers and ultimately the Gulf of Mexico, nitrogen export has continued to increase in Wisconsin and regionally (e.g. see https://fmr.org/minnesota-nitrate-study-highlights-farm-runoff-pollution). Further investigation into the high variation observed between years as well as the increasing winter and fall trend is needed.

Dissolved Oxygen

Adequate dissolved oxygen (DO) is critical to sustain aquatic life. The concentration of DO in water reflects the balance of consumption (through decomposition of organic material, plant and animal respiration and sediment demand), production (by photosynthesis), mixing with the atmosphere though diffusion and turbulence, and water movements depending on discharge and currents.

In 2020, DO was slightly higher than the long-term median in summer and fall, and only near the 10^{th} percentile for winter. While winter DO was relatively low, even at the ~10th percentile (Figure 2.2F) DO concentrations still exceeded the level of concern for fish and invertebrates (~5 mg/L) at more than 90% of sites. DO was often at or near 100% saturation, with hypoxic/anoxic conditions measured at less than 4% of sites for the year; the lowest DO measurements were largely bottom readings (~20 cm above the sediment interface) taken in backwaters during summer and winter. The LTRM SRS data (pool-wide medians 1993-2020) show a weak increasing trend in winter dissolved oxygen (DO), no trend in summer and weak decreasing trends in spring and fall.

Winter Snow and Ice

Median ice thickness and snow depth in 2020 were near the 25th percentile (Figure 2.3). The LTRM SRS pool-wide data show a weak increasing ice thickness trend and a weak decreasing snow thickness trend between 1993 and 2020. In winter, ice and snow cover can affect the concentration of DO in the underlying water column by regulating light transmission (and photosynthesis) and preventing gas exchange with the atmosphere. High under-ice DO suggests photosynthetic activity by phytoplankton or overwintering aquatic macrophytes.

Oxygen supersaturation under conditions of ice cover limiting diffusion of oxygen from water into the atmosphere along with high rates of photosynthesis has been implicated in past years as the cause of under-ice fish kills (from gas-bubble disease) in Pool 8, as well as other pools. Even though the ice and snow depth were relatively thin in winter 2020 (Figure 2.3), supersaturated DO (~110% saturation) was measured at only 1 of 150 sites, and values measured prior to 2020 have ranged to >300% under similar field settings. Higher discharge during winter 2020 may have kept water exchange rates high enough to buffer against high DO concentrations.

Figure 2.3. Box plots represent the 10th, 25th, 50th, 75th, and 90th percentiles of the medians

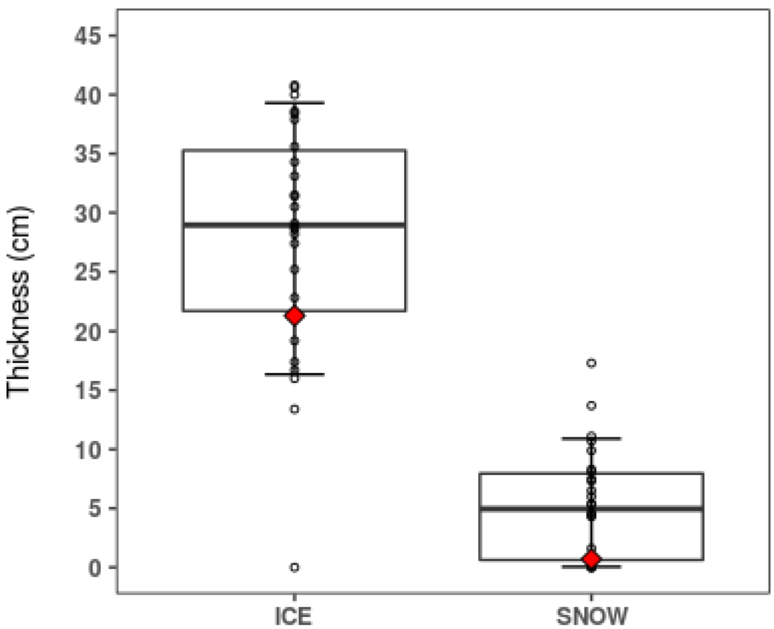


Figure 2.3. Box plots represent the 10th, 25th, 50th, 75th, and 90th percentiles of the medians by stratified random sampling during winter for the Long Term Resource Monitoring period of record (1993-2020). The diamonds represent the weighted pool-wide median for each parameter for winter SRS 2020.

Aquatic Vegetation

Methods

Aquatic vegetation surveys are conducted at 450 sites in Pool 8 annually, and sites are visited between 15 June and 15 August to target the period of peak biomass. Methods are described briefly here, but more detail on LTRM vegetation sampling protocol can be found in Yin et al., 2000. Sites are randomly selected at established stratum-specific densities to reflect relative coverage in the Pool 8 ecosystem, based on LTRM probabilistic design (https://www.umesc.usgs.gov/ltrmp/stats/statistics.html).

The boat is anchored within 10 m of site coordinates. Emergent species, rooted floating-leaf species and non-rooted floating-leaf species are assigned ordinal-scale cover scores based on their abundance in a 2- meter ring around the boat. At each site, submersed aquatic vegetation (SAV) is sampled in six subplots by pulling a modified garden rake over the sediment surface for a distance of ~1.5 m and SAV caught in the rake teeth is examined for species identification and abundance scoring. Filamentous algae on the rake is scored separately using the same scoring scheme. Submersed aquatic vegetation (SAV) caught on the rake is scored as "plant density" using a seven-level ordinal scoring scheme. Increasing plant density values represent increasing levels of stem density on the rake; score = 0 when no plants are on the rake, and scores of 1-5 are assigned to increasing numbers of plant stems (irrespective of length or branching density) caught on the rake. Rake teeth are marked in 20% intervals and plant density is scored as 1 if SAV fills rake teeth up to the first mark, scored as 2 if plant stems fall between the first and second intervals, etc. A seventh score was added in 2019 and is designated "trace" to describe very small amounts of SAV. A trace is equal to or less than plant material filling one gap in the rake tines up to the 20% level (~8% of a "1") and accounts for approximately 50% of observations previously scored as 1 (Drake et al. 2021).

Specific features of the Pool 8 aquatic vegetation are based on data spanning 1998 – 2020, and data were downloaded from the LTRM graphical data browser at: https://www.umesc.usgs.gov/data_library/vegetation/graphical/veg_front.html

Results

Surveys were conducted at 444 out of the 450 scheduled sites between 22 June and 13 August in 2020. After several consecutive years of high water, discharge was near the long-term average during the 2020 growing season (Figure 3.1). Three of the unsampled sites were unreachable due to low water conditions and recent sedimentation. Three were located under boat houses and were unreachable.

Pool-wide detection rates of aquatic vegetation remained at the generally high levels that have been documented since the mid-2000s. The Pool 8 vegetation field crew noted a visibly high abundance of American lotus (*Nelumbo lutea*) and arrowheads (*Sagittaria rigida and S. latifolia*) relative to recent years, likely a result of shallower water. The observed increase was not reflected in percent frequency occurrence, but percent cover of the combined arrowheads increased from 3% in 2019 to 5.2% in 2020. Additionally, in 2020 the invasive flowering rush (*Butomus umbellatus*) made a sudden, widespread appearance in the lower half of Pool 8 and was also reported in LTRM Pools 4 and 13.

Long-term patterns in vegetation abundance

Since LTRM probabilistic monitoring was initiated in 1998, the prevalence of all three major vegetation life forms (submersed, rooted floating-leaf and emergent) in Pool 8 has increased (Figure 3.1). The prevalence of non-rooted floating species (duckweeds and water fern) and filamentous algae have varied considerably over time and likely reflect short term changes in discharge, temperature and water residence time.

Figure 3.1. Pool-wide prevalence of the three vegetation life forms over 23 years of probabilistic monitoring (±SE).

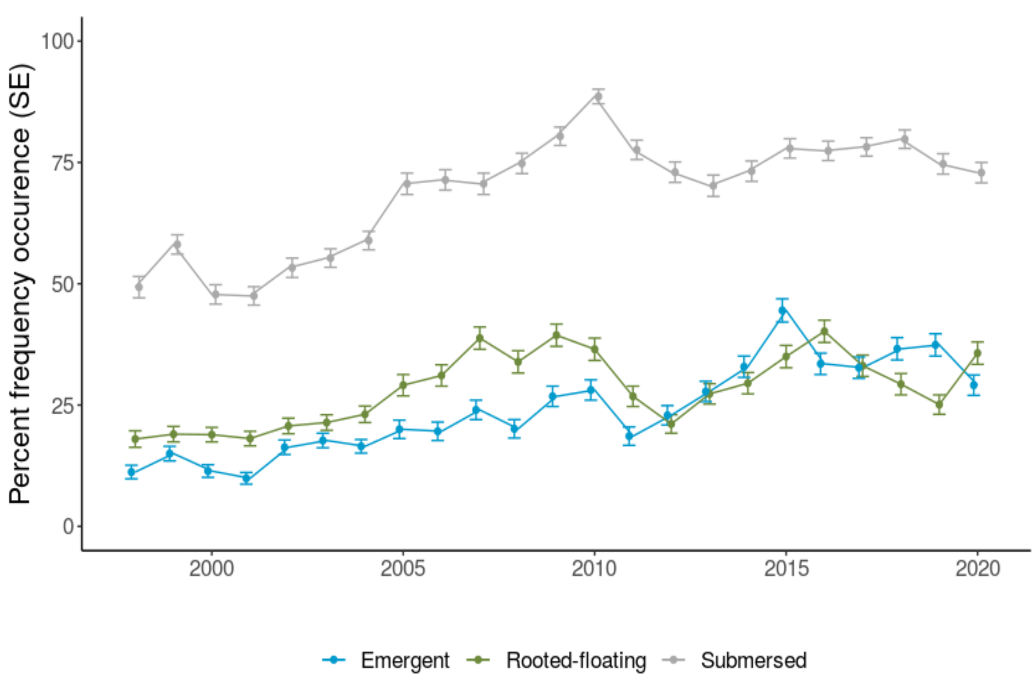


Figure 3.1. Pool-wide prevalence of the three vegetation life forms over 23 years of probabilistic monitoring (±SE).

While the overall prevalence of aquatic macrophytes remained relatively high in 2020, the percent frequency occurrence of submersed species decreased slightly to 72.9% in 2020 from 74.7 -79.8% in the preceding 5 years (Figure 3.1). Field crews observed extremely robust growth and flowering of rooted-floating leaf species (especially American lotus) throughout Pool 8 in 2020. Despite recent years of steady decline, the prevalence of rooted-floating leaf species increased from 25.1 in 2019 to 35.7% in 2020 (Figure 3.1). This increase is likely associated with shift from sustained high water to the near-average growing season discharge in 2020. The prevalence of emergent species has generally increased over the period of monitoring, although the species driving this increase have shifted from the *Sagittarias* which increased between 1998 and ~2010 to wild rice (*Zizania aquatica* L.) which expanded considerably beginning in the mid-2000s (Figure 3.2).

Figure 3.2. Pool-wide prevalence of the most common emergent species detected

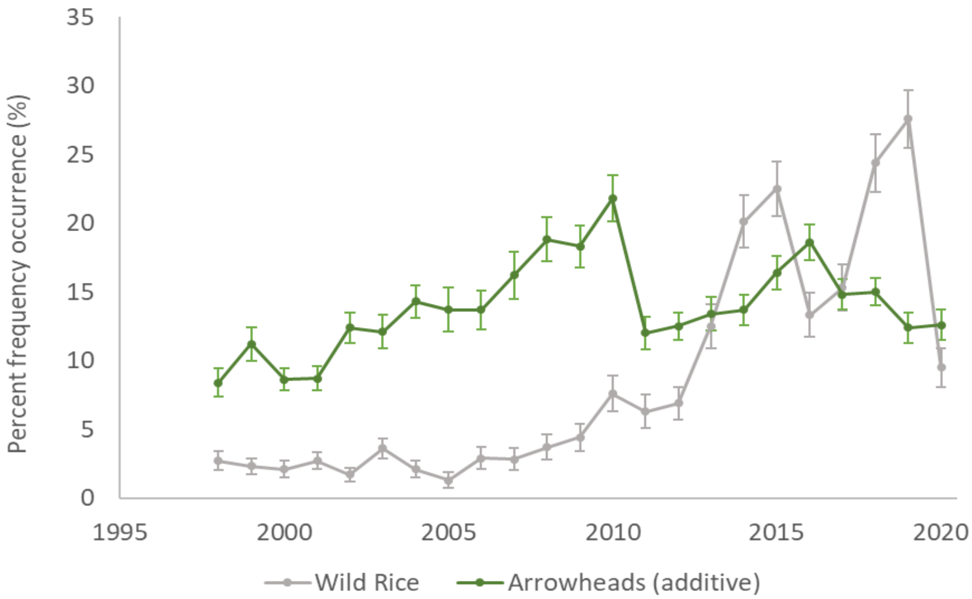


Figure 3.2. Pool-wide prevalence of the most common emergent species detected in LTRM surveys, and standard errors. Arrowheads represent the summed percent frequency occurrence and standard errors of *Sagittaria latifolia* and *S. rigida*.

Patterns in aquatic vegetation by LTRM stratum

Vegetation abundance varied considerably among strata, with slow-moving and still waters (the backwater isolated, backwater contiguous, and impounded strata) generally supporting more aquatic vegetation than swift waters (side channels and the main channel borders) (Table 3.1, Figure 3.3). Stratum-specific average depths at the time of sampling in 2020 were, on average, ~28 cm shallower than the previous four years (excluding backwater isolated).

Table 3.1. Summary of site distribution among strata for aquatic vegetation sampling in 2020. The column "% Vegetated" was calculated by subtracting the number of unvegetated sites from the total number of sites in each stratum and dividing by the number of sites sampled in that stratum. Depths were measured at time of sampling and are not corrected for river stage – reported depths provide only a general indication of differences.

Table 3.1. Summary of site distribution among strata for aquatic vegetation sampling in 2020

Stratum	Number of sites	2020 mean depth m (SD)	2020 % Vegetated
Backwater connected (BWC)	108	0.64 (0.58)	92.6%
Backwater isolated (BWI)	18	0.71 (1.18)	94.4%
Impounded (IMP)	184	1.19 (0.58)	81.5%
Main channel border (MCB)	70	1.94 (1.50)	24.3%
Side channel (SC)	64	1.55 (1.21)	40.6%

Figure 3.3. Prevalence of life forms by stratum in 2020.

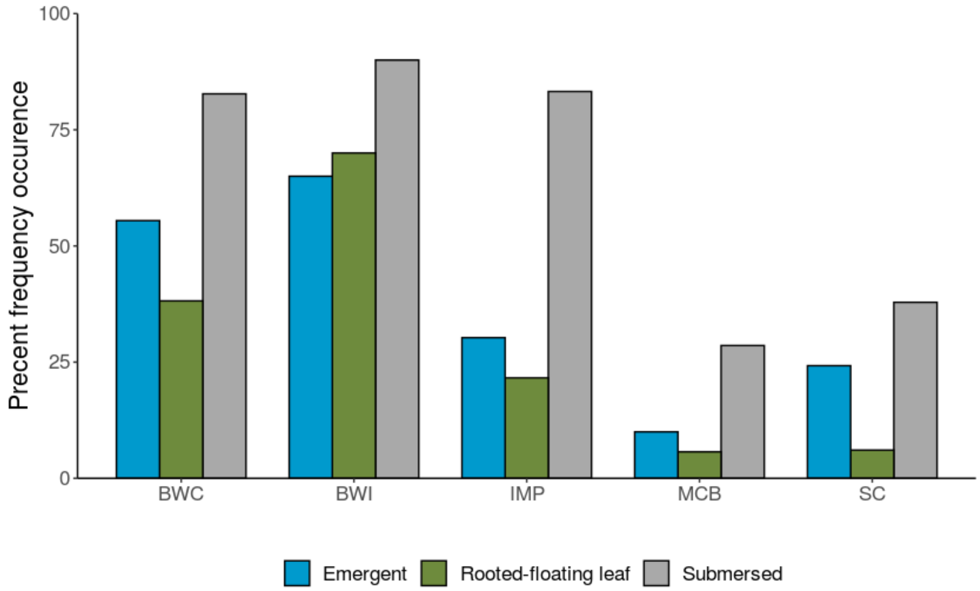


Figure 3.3. Prevalence of life forms by stratum in 2020.

Aquatic vegetation species of interest

A total of 34 aquatic plant species plus filamentous algae have been identified in Pool 8 over the course of LTRM monitoring. Between 4 and 8 species are usually detected at vegetated sites. The maximum number of species found at a single site in 2020 was 18. The highest diversity sites usually span a range of depths and include the transition from submersed species to emergent species (i.e. are near the edge of the land-water boundary).

A considerable portion of the increase in aquatic vegetation over the LTRM monitoring period is attributable to the expansion of two native species of special interest – wild celery and wild rice. Wild celery (*Vallisneria americana* Michx.) is a predominantly clonal, perennial plant, and has high specific value as forage for canvasback (*Aythya valisineria* Wilson) and other migrating waterfowl. Wild rice, an annual aquatic grass, can also be an important source of food and cover for wildlife. Long-term data show considerable increases in the prevalence of both species since 1998 (Figure 3.4). Wild celery in the impounded stratum of Pool 8 is currently ~6x more prevalent than it was in 1998-2001. The detection rate, however, appears to have declined slightly from a maximum in 2015, and may have been influenced by periods of high discharge and deeper water in during the 2016 – 2019 growing seasons. Despite this recent decrease, its current prevalence is still relatively high (~38% pool-wide percent frequency occurrence in 2020; Figure 3.4). The detection rate of wild rice in Pool 8 has increased by approximately 10-fold since the early 2000s, most dramatically in the impounded stratum. Wild rice was detected at 1-3 % of sites annually between 1998 and 2008 but was detected at ~ 28% of sites in 2019, its year of highest recorded abundance (Figure 3.4). In 2020, however, detection rates decreased substantially (only ~10% of sites). High detection frequency despite sustained high water in the spring of 2018 and 2019 suggests that wild rice tolerates high water velocity and low light conditions in its early stages of germination and development. Interestingly, the highest frequencies of wild rice were observed in the years of highest growing season discharge and depth. Despite the decline in prevalence in 2020, wild rice was still the most frequently detected emergent species in Pool 8 LTRM surveys.

Figure 3.4. Trends in the pool-wide detection of wild celery and wild rice in Pool 8 over the period of LTRM vegetation SRS monitoring.

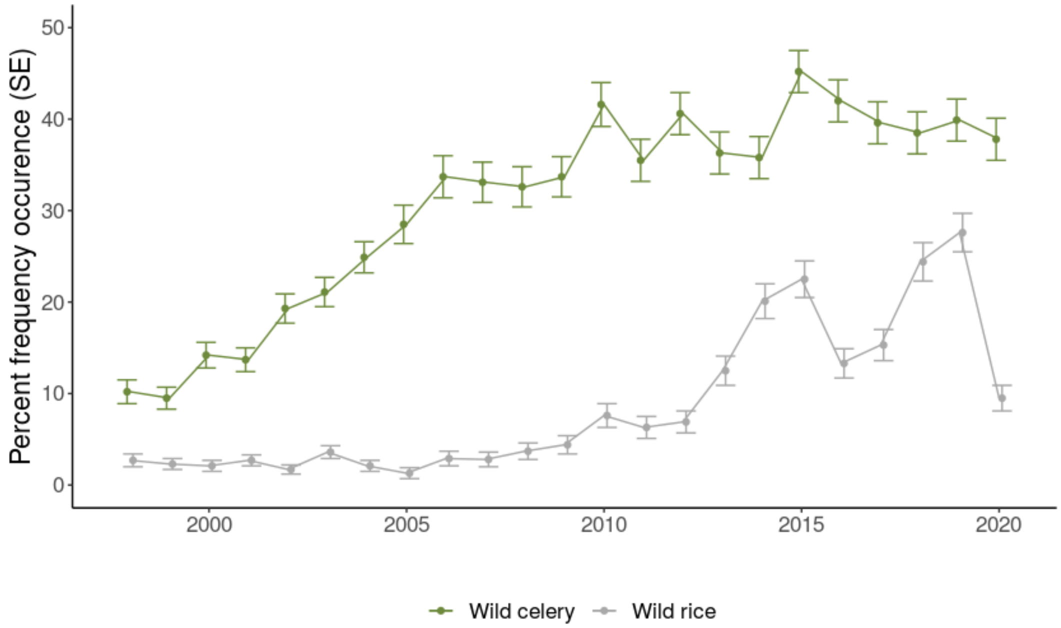


Figure 3.4. Trends in the pool-wide detection of wild celery and wild rice in Pool 8 over the period of LTRM vegetation SRS monitoring.

The Pool 8 aquatic vegetation community is composed primarily of native species, with only two, locally abundant invasive SAV species: Eurasian watermilfoil (*Myriophyllum spicatum* L.) and curly pondweed (*Potomogeton crispus* L.) (Figure 3.5). These species have been detected at ~10-30% of Pool 8 sites annually, but have not increased as dramatically as the native species described above. Although sometimes locally abundant, the invasive species rarely appear to exclude native vegetation at the site level and are virtually never the only species detected at a site. In most years, the maximum biomass of curly pondweed occurs in early- to mid-May, and it senesces considerably by the time summer surveys are conducted. In 2020, the invasive emergent flowering rush (*Butomus umbellatus)* made a sudden, widespread appearance in the lower half of Pool 8. It was detected at 7 LTRM sites, and large areas comprising an estimated tens of thousands of plants were documented. Only a single plant had been observed in Pool 8 by LTRM staff prior to 2020.

The prevalence of native Northern watermilfoil (*M. sibiricum* Kom.) increased substantially and suddenly in 2015 and has remained at levels comparable to the Eurasian watermilfoil since then (Figure 3.5). This pattern was also observed in Pools 4 and 13 beginning in the same year. Although we most frequently encounter individuals that are clearly either the native (most leaves are "open" with 4-11 leaflets) or the invasive (most leaves are "folded" with >16 leaflets), we also find hybrids with intermediate numbers of leaflets and other morphological features. In cases where plants appear to be hybrids, those with > 11 leaflets are categorized as *M. spicatum*, and those with 11 or fewer are categorized as *M. sibiricum*.

Figure 3.5. Prevalence of the two common submersed invasive species, curly pondweed and Eurasian watermilfoil, and the native Northern watermilfoil in Pool 8 over LTRM monitoring.

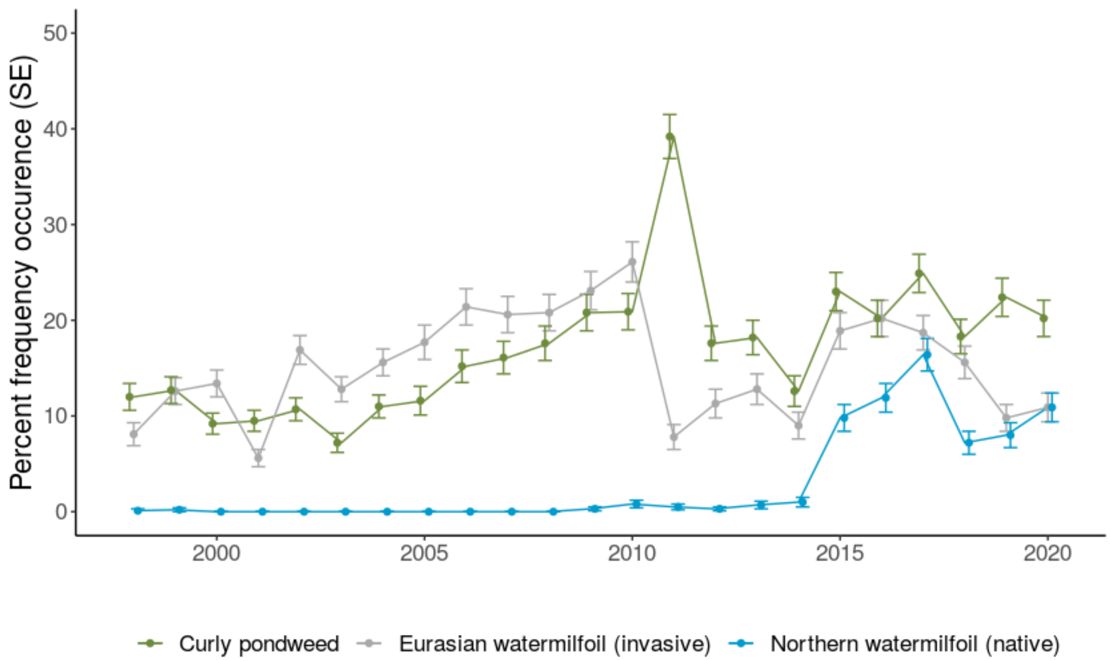


Figure 3.5. Prevalence of the two common submersed invasive species, curly pondweed and Eurasian watermilfoil, and the native Northern watermilfoil in Pool 8 over LTRM monitoring.

The profusion of algae in freshwater systems is associated with eutrophication, a major concern for managers of the greater Upper Mississippi River and freshwater ecosystems in general. Filamentous algae are often found in Pool 8 in dense mats or clinging to vegetation, and late each summer blue-green algae appear as patchy films. Non-rooted floating species (duckweeds and water fern) provide food for waterfowl and valuable habitat for macro-invertebrates. However, non-rooted floating species can reduce sunlight penetration and cause oxygen depletion at high densities. The prevalence of filamentous algae and non-rooted floating species has varied considerably over time in LTRM surveys and likely reflect short term changes in discharge (Figure 3.6). Detection rates were relatively high in 2020 (~26% of sites), but in most cases they were sparse and did not reach “nuisance” levels.

Figure 3.6. Prevalence of filamentous algae and all duckweed species combined over the period of LTRM monitoring.

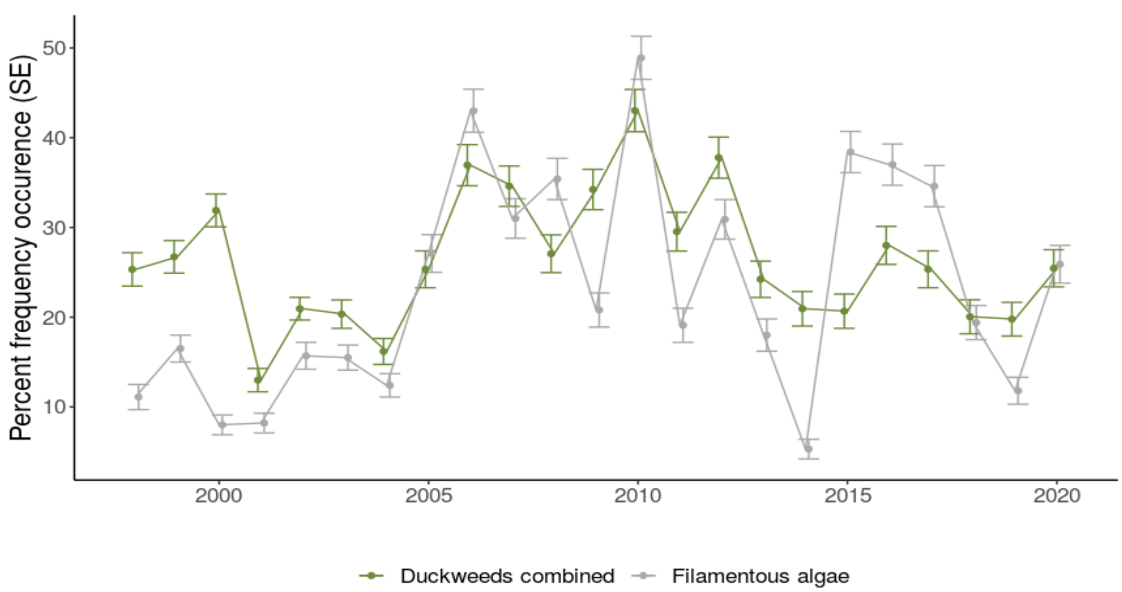


Figure 3.6. Prevalence of filamentous algae and all duckweed species combined over the period of LTRM monitoring.

Fisheries

Methods

The LTRM fish component uses six standardized gear types, including daytime electrofishing, fyke nets, mini fyke nets, large- and small-hoop nets, and otter trawls, within a stratified random sampling scheme (SRS) and stratification based on broad habitat features. Fish sampling is conducted within three consecutive six-week episodes (periods 1 – 3), from June 15 to October 31, to ensure both temporal and spatial interspersion of the sampling gear deployments. The same number of gear-stratum combinations are fished each time period, but sites are independently selected for each episode. More detail on LTRM fish sampling procedures can be found in Ratcliff et al., 2014 at: https://pubs.usgs.gov/mis/ltrmp2014-p001/. A companion document (Ickes et al., 2014) describes the monitoring rationale, strategy, issues, and methods, and can be found at: https://pubs.usgs.gov/mis/ltrmp2014-p001a/.

The LTRM Fish Graphical Data Browser automates many routine analyses and provides on-demand analytical products for end users. This information can be accessed at: https://umesc.usgs.gov/data_library/fisheries/graphical/fish_front.html. Routine data analyses for overall fish community data include sample allocation, species richness, total catch by species, and community composition (presence/absence). Stock size designations defined in published manuscripts are among many useful descriptive parameters that can be found in the LTRM Fish Life History Database, available for download at https://umesc.usgs.gov/data_library/fisheries/fish_page.html. The life history database also contains a table with allometric growth information that allows conversion of length data to mass, which yields additional insight into fish community characteristics.

This report summarizes sampling effort, total catches, species richness, and dominant species in the catch, by number and weight. Detection frequencies of common and rare fishes are discussed, and data on species of special concern are also presented. Shannon-Wiener Diversity Index (Zar 1984) scores are computed from day electrofishing collections to indicate fish community diversity relative to previous years. Any collections of bigheaded carps will be reported, as well as Common Carp status, and other anecdotal observations on the fish community.

Catch-per-unit-effort (CPUE) data are provided for ten common sport fish of interest to anglers and fish managers. CPUE is reported as estimates of gear-specific pool-wide means and standard errors, weighted for effort expended within each of the sampling strata. Herein, we present CPUE data for one or two effective gear types, as suggested by total catches from each gear. More detailed descriptions of CPUE calculations can be found at the Fish Monitoring Rationale and Fish Procedures web pages, listed above.

A stock-size analysis for these same ten common sport fish of interest displays the catch of fish in each stock category, annually, in stacked bar graphs, with substock catches in separate figures due to their generally higher numbers. Stock categories are based upon those listed in the Life History Database, referenced above. The stock-size analysis includes catches from all gear types and sampling sites.

Data omissions and limitations (1993 – 2020)

Daytime electrofishing and tailwater otter trawling were omitted in 2020 because of crew size limitations due to the Covid-19 pandemic. 2020 catches from wingdam and fixed tailwater sites are reported in total catch, species richness, and the stock analyses, but are excluded from CPUE calculations because these strata were considered too small and unique for proper stratification of sampling effort. However, CPUE values for the individual strata, including wingdam sites, are available on the Fish Graphical Data Browser at the link provided above. In 2003, no fisheries data were collected due to budget restrictions. In 2005-2009 time period 1 sampling was not conducted.

Results

Effort by gear type and period

LTRM Pool 8 fish sampling in 2020 was significantly reduced due to COVID-19 protocols that precluded three-person sampling crews. Thus, standardized daytime electrofishing and tailwater trawling were forgone in all time periods. All other netting was completed. In total, 174 samples were collected of 270 planned. This loss of sampling effort was unfortunate, as the normal flow regime during the sampling season provided ideal conditions to collect data.

The LTRM fish sampling allocation among gear types has remained stable for many years but changed considerably in 2020 for the reasons described above. In 2020, sampling effort was highest for mini fyke nets (66 collections) and fyke nets (48 collections). Under normal circumstances, electrofishing would include an additional ~90 collections, and trawling and additional 12 collections. Effort in 2020 was greatest in the contiguous backwater stratum (60 collections), with side channel (36 collections) and main channel border (36 collections) also receiving considerable effort. The impounded shoreline stratum received the least effort as it is primarily sampled via electrofishing. Please note that although the strata names imply habitat features, a wide variety of habitat conditions exist within each stratum.

Catch and species richness

Total catch in 2020 was 14,375 fish, and the catch per sample value was slightly higher than in 2019 (Figure 4.1) despite the lack of daytime electrofishing. The 2019 catch per sample value, however, was likely low as a result of the persistent high discharges of 2019. Mini fyke nets (11,015) had the highest catches, accounting for nearly 77% of the total catch. Fyke netting yielded the second highest catch of 2,941 fish. Species richness in 2020 was lower than usual at only 48, reflective, again, of the absence of daytime electrofishing.

Figure 4.1. Catch per sample and annual species richness

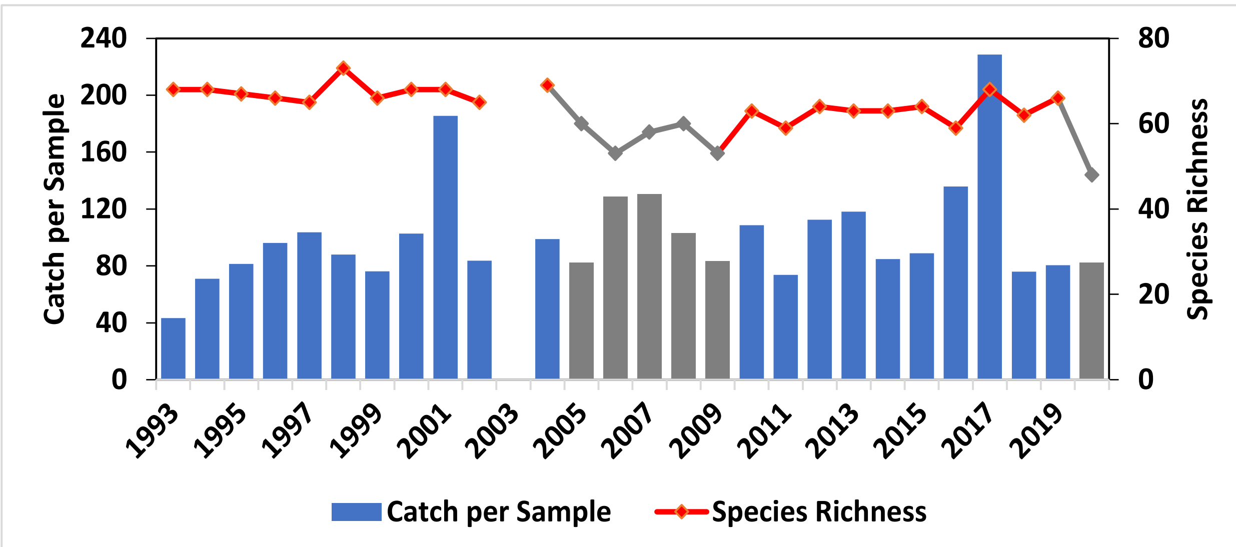


Figure 4.1. Catch per sample and annual species richness for Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element fish collections in Pool 8 of the Upper Mississippi River. Data represent samples collected with daytime electrofishing, fyke nets, mini fyke nets, large and small hoop nets, and otter trawls. Data are omitted for 2003 due to limited sampling that year. Gray shading indicates limited sampling and includes when Period 1 (June 15 – July 31) was not sampled from 2005-2009, and when daytime electrofishing was not accomplished in 2020.

Weed Shiner (7,548), Bluegill (2,374), Spotfin Shiner (804), Yellow Perch (391), and Largemouth Bass (377), were the top 5 species, in order of catch, in 2020 (Figure 4.2a). These top five species comprised 80% of the catch. No other species surpassed 300 individuals for the year, but the next most abundant were Black Crappie, Mimic Shiner, and Pumpkinseed Sunfish.

By weight (Figure 4.2b), Bowfin (187 kg) ranked first in the catch, followed by Channel Catfish (179 kg), Common Carp (173 kg), Bluegill (112 kg), and Flathead Catfish (104 kg). The top five species accounted for about 59% of the total weight. No other species yielded over 100 kg in 2020, but Northern Pike, Freshwater Drum, and Shorthead Redhorse had the next heaviest weights.

Figure 4.2. Top species by a) catch and b) weight

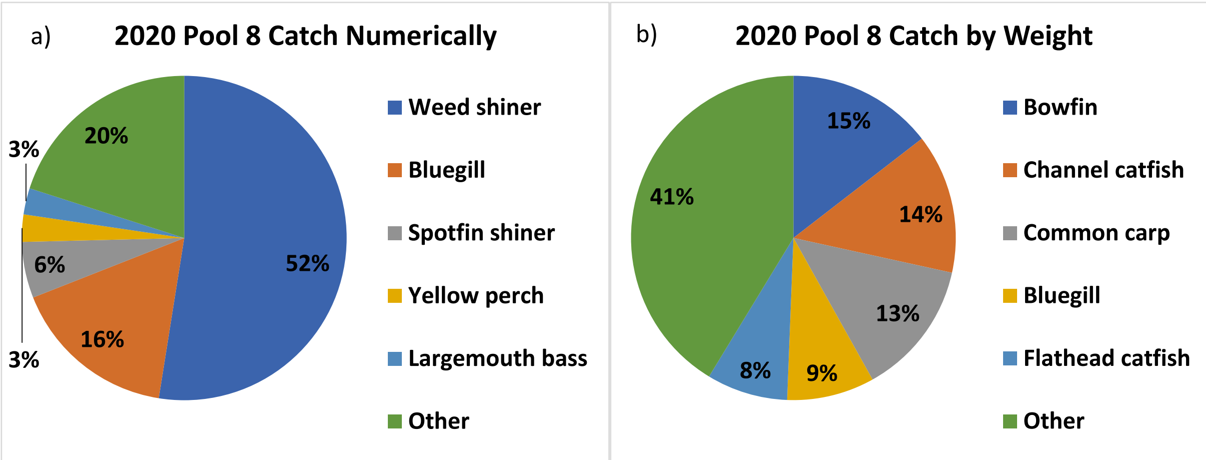


Figure 4.2. Top species by a) catch and b) weight in samples from Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element fish collections in Pool 8 of the Upper Mississippi River during 2020. Data represent samples collected with fyke nets, mini fyke nets, large and small hoop nets.

Fish community structure

Shannon-Wiener Diversity Index (SWDI) was not calculated for 2020, as the standardized daytime electrofishing used to calculate the score was prohibited by WDNR Covid-19 policy.

Species representation in 2020

Appendix A lists all fish species collected in LTRM Pool 8 samples, and number of years collected.

Historically, 37 species have been detected in Pool 8 LTRM samples every year since SRS began in 1993. Quillback fell out of that group in 2020, but the remaining 36 species were all accounted for. An additional 27 species have been detected in at least half of the years, including five species which have been collected in all but a single year. We collected 11 species from that group in 2020.

Twenty-eight species have been detected in fewer than half of sampling years. The only one of those relatively rare species that we collected in 2020 was Blackside Darter. None of the 13 rarest species (captured in only one or two years) were sampled, nor were any new species collected, in 2020. Thus, the LTRM fish species total in Pool 8 remains 91.

We caught two River Redhorse (Wisconsin-listed threatened species) in the 2020 Pool 8 LTRM sampling season. We also caught 7,548 Weed Shiners, 9 Mud Darters, and 1 Pugnose Minnow, each listed as species of special concern.

Through 2020, the Pool 8 LTRM sampling efforts have not detected any Asian carp (Bighead, Silver, or Black). This year, we caught 88 Common Carp, currently the only non-native fish species of significance in Pool 8. Common Carp are thought to be in systemic decline in the UMR. They continue to be among the dominant species, by weight, of all species in Pool 8, but fell to third place in 2020. This decline was likely due to the omission of daytime electrofishing, rather than a precipitous decrease in biomass. The CPUE graph of fyke netting for Common Carp (Figure 4.4) shows a stable long-term pattern, with a recent short-lived increase. It is unfortunate that electrofishing data were sacrificed in 2020. Hopefully, no major changes were missed due to restricted sampling in 2020, as may have happened when sampling was omitted in 2003, around a time when a major shift in the carp population was indicated by the fyke netting data.

Figure 4.4. Catch per unit effort (± 1SE) of Common Carp by fyke netting samples

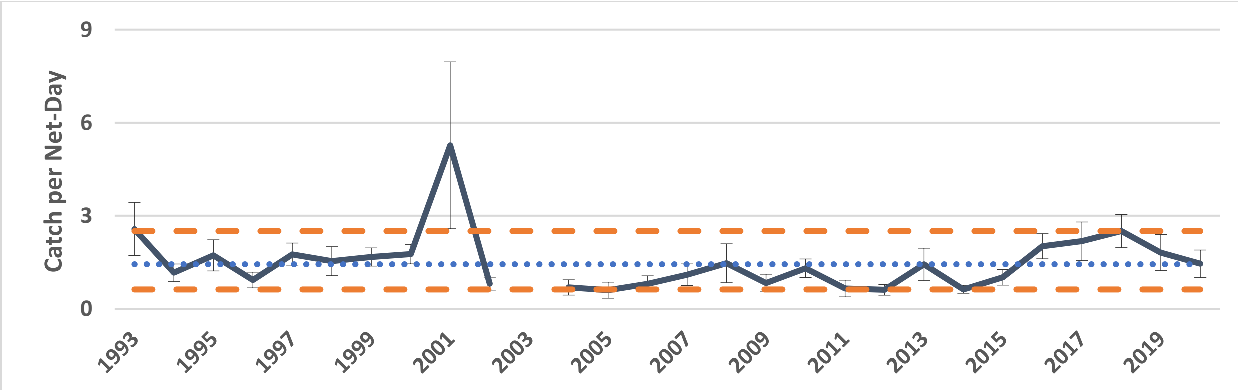


Figure 4.4. Catch per unit effort (± 1SE) of Common Carp by fyke netting samples from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element fish collections in Navigation Pool 8 of the Upper Mississippi River. Data are omitted for 2003 due to limited sampling that year. The long-dashed lines on the CPUE graphs represent the 10th and 90th percentiles and the dotted line represents the long-term average for the period of record (1993-2020).

In summary, reduced 2020 LTRM fish monitoring results do not indicate a major change from recent years. Despite the absence of the most unbiased, and arguably, most productive sampling gear, most common species were detected, and in similar proportion to the ranks from recent years. Several rare species were recorded, as usual. Community diversity was not calculated. New invasive species were not detected, and Common Carp abundance seems similar to recent years.

Species of Interest Data

Black Crappie

Total catches of Black Crappie from all standard LTRM gear types combined have ranged from 269 in 2009 to 1,693 in 1994. We caught 288 Black Crappies in 2020 with only the reduced gear types described above. Black Crappie fyke net CPUE remained stable in 2020 (Figure 4.5), again near the tenth percentile for all years. Fyke net CPUE for Black Crappie has only exceeded the long-term average twice since 2007, and its overall pattern is negatively correlated with the prevalence of submersed aquatic vegetation in Pool 8 (e.g. Fig 3.1).

Figure 4.5. Catch per unit effort (± 1SE) of Black Crappie by fyke netting samples

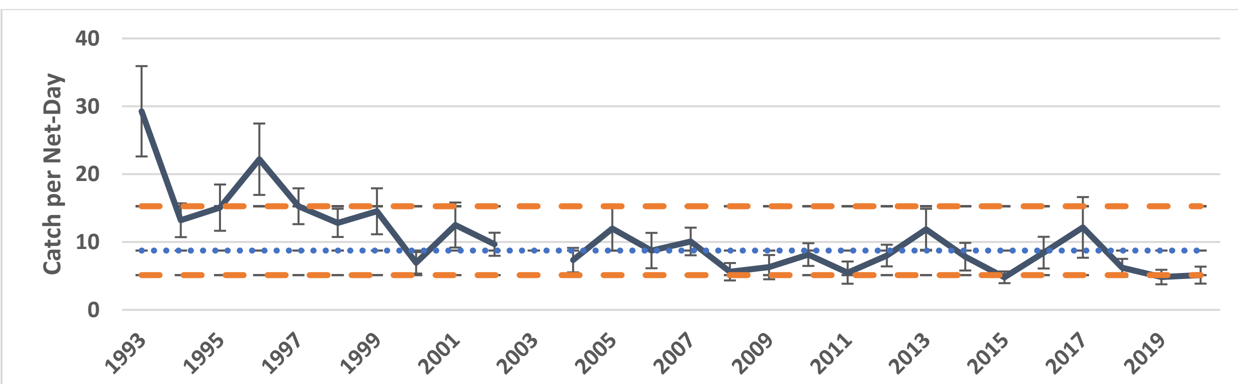


Figure 4.5. Catch per unit effort (± 1SE) of Black Crappie by fyke netting samples from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element fish collections in Navigation Pool 8 of the Upper Mississippi River. Data are omitted for 2003 due to limited sampling that year. The long-dashed lines on the CPUE graphs represent the 10th and 90th percentiles and the dotted line represents the long-term average for the period of record (1993-2020).

Catch of substock-size (<130 mm total length (TL)) Black Crappie (Figure 4.6) was again far below the long-term average in 2020, and one of the lowest catches of the LTRM era. The substock graph suggests Black Crappies have consistently low reproductive success in most years, with a stronger year class produced every three to four years.

Figure 4.6. Catch of substock-sized Black Crappie annually in Navigation Pool 8

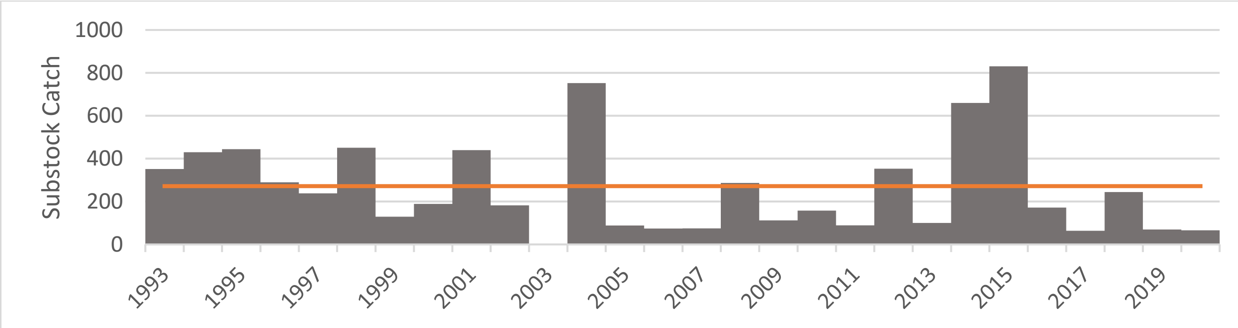


Figure 4.6. Catch of substock-sized Black Crappie annually in Navigation Pool 8 of the Upper Mississippi River by all gears combined from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element. The horizontal line indicates long-term average catch of substock-sized fish. Data are omitted for 2003 due to limited sampling that year.

The proportions of preferred- (250-299 mm TL) and memorable-size (>300 mm TL) Black Crappie in 2020 (Figure 4.7) were smaller than in recent years, although this could be an artifact of reduced sampling effort. Although the number of stock-sized fish increased in consecutive years since an all-time low in 2018, the graph shows a distinct reduction in this category since about 2000. This pattern is similar to the decline in fyke net CPUE. The most plausible reason for a decline of these intermediate-sized Black Crappie, based purely upon pattern correlation, seems to be the rebound in submersed aquatic vegetation that occurred after a nearly complete crash in the early 1990's, and perhaps associated increases in water clarity.

Figure 4.7. Catch of stock- through memorable-sized Black Crappie annually in Navigation Pool 8

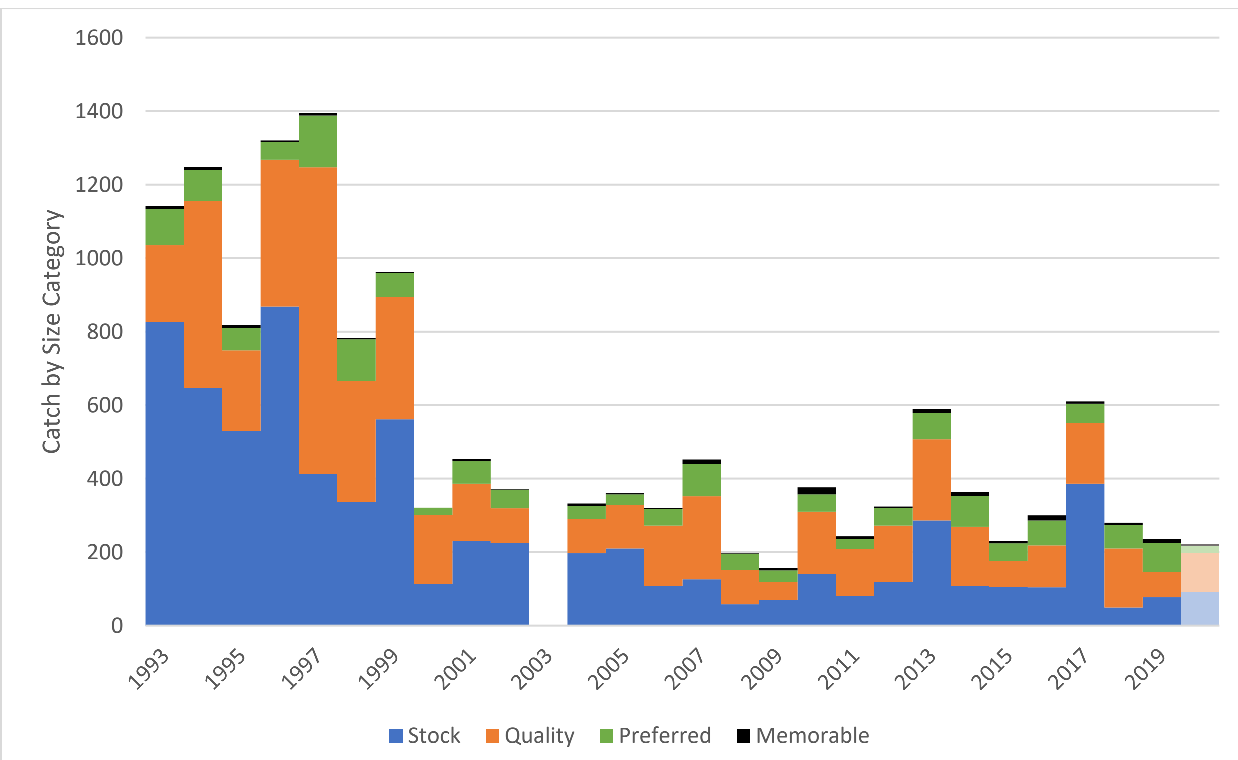


Figure 4.7. Catch of stock- through memorable-sized Black Crappie annually in Navigation Pool 8 of the Upper Mississippi River by all gears combined from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element. Data are omitted for 2003 due to limited sampling that year. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

Bluegill

Total catches of Bluegill from all standard LTRM gear types combined have ranged from 1,685 in 1994 to 12,005 in 2010. We caught 2,374 Bluegill in 2020. Bluegill fyke net CPUE (Figure 4.8) during the first decade of LTRM fish sampling was low, and increased slowly. From 2005 to 2013 Bluegill CPUE was high and variable. Since 2013, fyke net CPUE has fluctuated between the tenth percentile and the mean. In 2020 it again approached the long-term average. Low Bluegill catch rates in the early 1990's was attributed to the system-wide crash of submersed aquatic vegetation; however, aquatic vegetation in Pool 8 has been abundant since ~2010, and catch rates have become low again. Increasing CPUE in 2020, a year of moderate flows (see Chapter 1), could either be due to an increase in the population or increased gear efficiency.

Figure 4.8. Catch per unit effort (± 1SE) of Bluegill by fyke netting samples

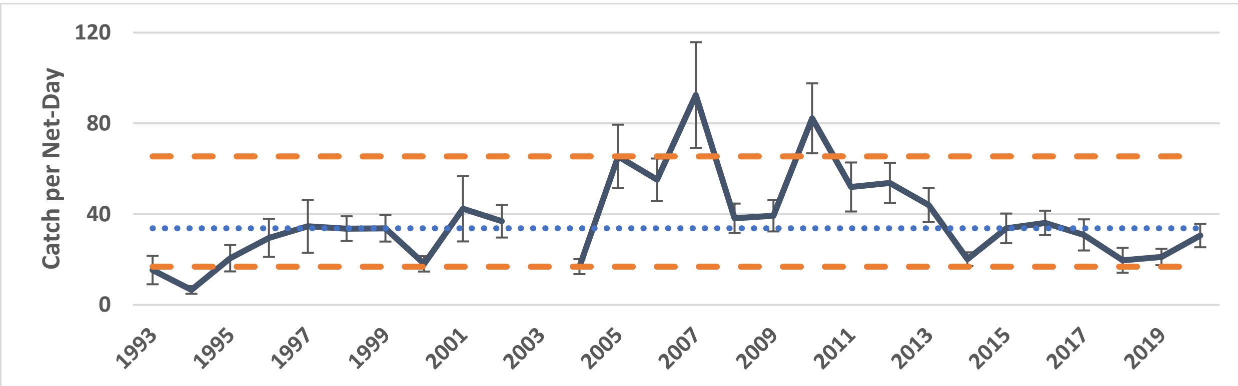


Figure 4.8. Catch per unit effort (± 1SE) of Bluegill by fyke netting samples from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element fish collections in Navigation Pool 8 of the Upper Mississippi River. Data are omitted for 2003 due to limited sampling that year. The long-dashed lines on the CPUE graphs represent the 10th and 90th percentiles and the dotted line represents the long-term average for the period of record (1993-2020).

Catches of substock-sized (<80 mm TL) Bluegill (Figure 4.9) in 2020 were the lowest in the history of the program, but were likely attributable to sampling reductions. Some first-year Bluegills were collected, and if electrofishing samples had been collected, substock catches may easily have approached those of recent years.

Figure 4.9. Catch of substock-sized Bluegill annually in Navigation Pool 8

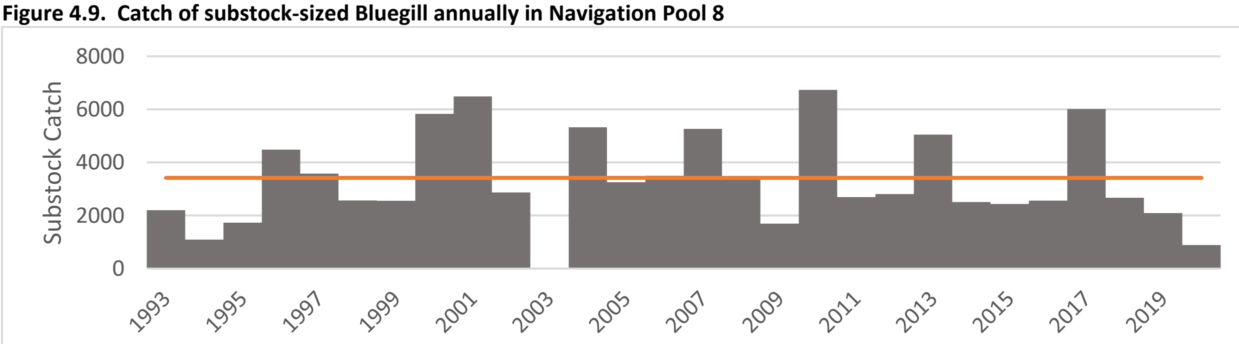


Figure 4.9. Catch of substock-sized Bluegill annually in Navigation Pool 8 of the Upper Mississippi River by all gears combined from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element. The horizontal line indicates long-term average catch of substock-sized fish. Data are omitted for 2003 due to limited sampling that year.

Although no memorable-size (>250 mm TL) Bluegill were caught in 2020 (Figure 4.10), about 4.4% of the catch was preferred-size (200-249 mm TL), similar to most recent years. The number of quality-sized (150-199 mm TL) Bluegill seems stable, relative to the high variability in the number of stock-sized fish. The number of substock-sized Bluegill does not seem to translate into stock-sized fish the next year or following. This would suggest that external forces, such as climate, hydrology, or overwintering habitat availability? are acting to shape the number of Bluegills that survive to larger sizes.

Figure 4.10. Catch of stock- through memorable-sized Bluegill annually in Navigation Pool 8

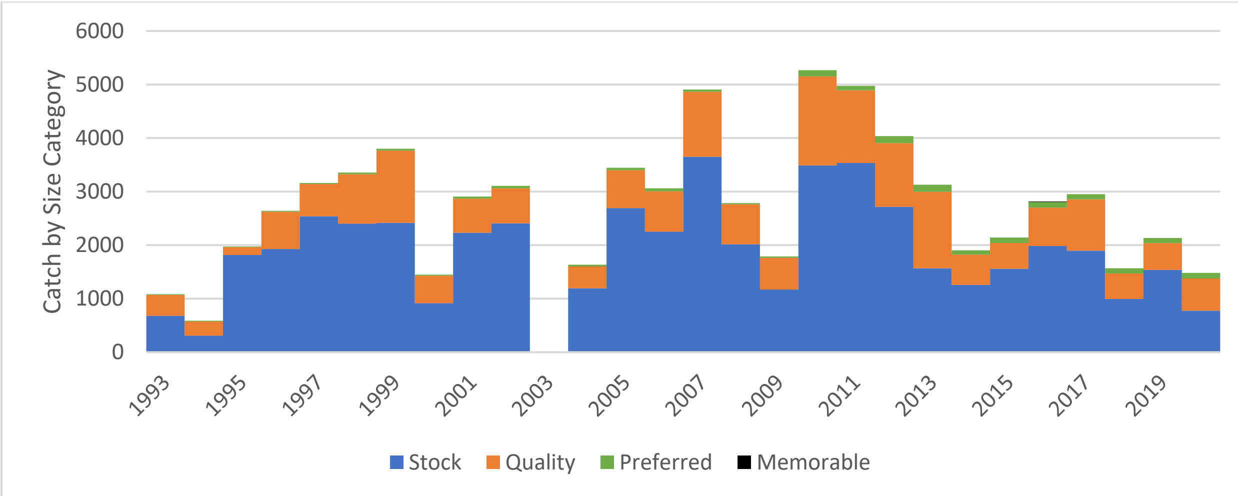
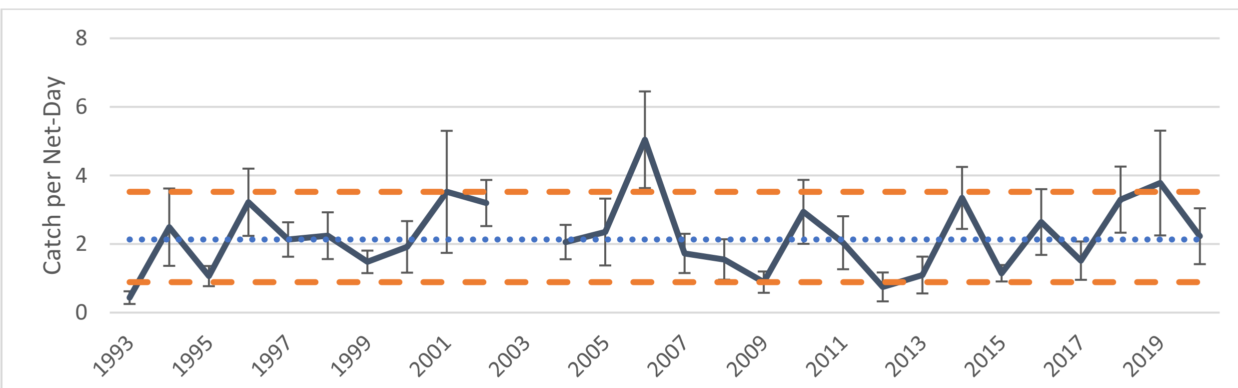


Figure 4.10. Catch of stock- through memorable-sized Bluegill annually in Navigation Pool 8 of the Upper Mississippi River by all gears combined from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element. Data are omitted for 2003 due to limited sampling that year.

Channel Catfish

Total catches of Channel Catfish from all standard LTRM gear types combined have ranged from 85 in 2009 to 785 in 1994. We caught 204 Channel Catfish in 2020 with the reduced gear types described above. Channel Catfish CPUE decreased in 2020 for large-hoop nets (Figure 4.11 top) back to the long-term average for LTRM SRS years. Small-hoop netting CPUE (Figure 4.11 bottom), which best represents younger year classes, has been low for many years and declined in 2020 to the tenth percentile. The overall CPUE trends suggest stability, with perhaps a shift from small hoop nets being more effective earlier to large hoop nets being better in recent years. Still, every fish population needs to replace itself over time, and it bears watching that new year classes seem largely absent in the small nets.

Figure 4.11. Catch per unit effort (± 1SE) of Channel Catfish by large-hoop netting (top graph) and small-hoop netting (bottom graph)



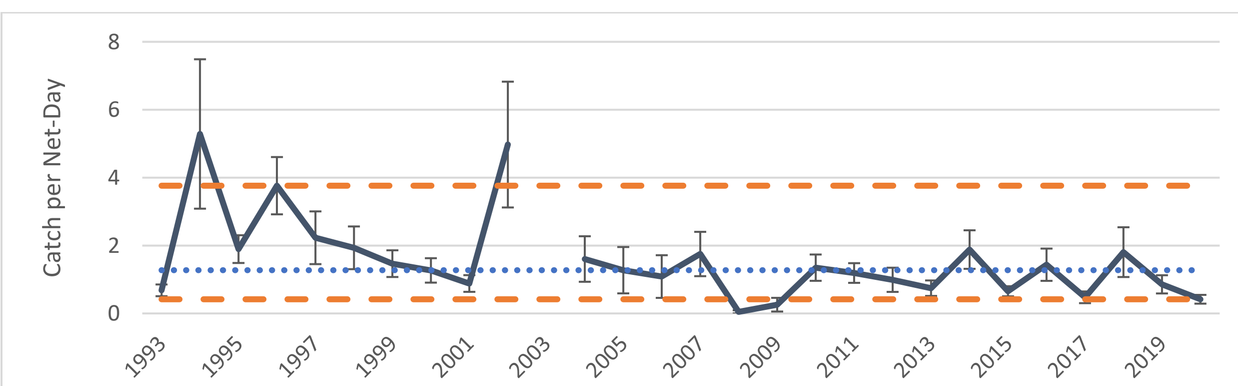


Figure 4.11. Catch per unit effort (± 1SE) of Channel Catfish by large-hoop netting (top graph) and small-hoop netting (bottom graph) samples from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element fish collections in Navigation Pool 8 of the Upper Mississippi River. Data are omitted for 2003 due to limited sampling that year. The long-dashed lines on the CPUE graphs represent the 10th and 90th percentiles and the dotted line represents the long-term average for the period of record (1993-2020).

Substock-sized (<280 mm TL) Channel Catfish were far more abundant in the Pool 8 catch during the first decade of SRS fish sampling for LTRM than since (Figure 4.12). Many of these were probably caught by trawling, although the CPUE for small-hoop nets depict a decline. One positive is that we caught 57 substock-sized Channel Catfish in 2020, the most since 2004. Perhaps the 2020 year class will become the population's backbone for the next decade or more.

Figure 4.12. Catch of substock-sized Channel Catfish annually in Navigation Pool 8

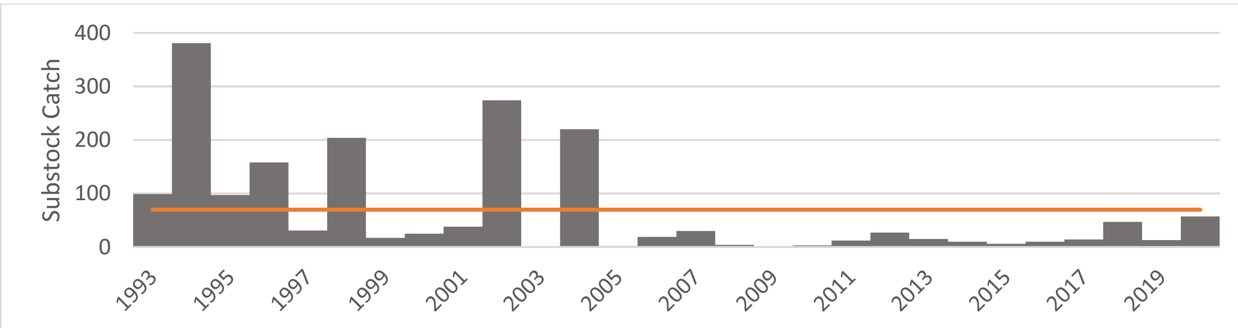


Figure 4.12. Catch of substock-sized Channel Catfish annually in Navigation Pool 8 of the Upper Mississippi River by all gears combined from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element. The horizontal line indicates long-term average catch of substock-sized fish. Data are omitted for 2003 due to limited sampling that year.

Stock- (280-409 mm TL) and quality-sized (410-609 mm TL) Channel Catfish dominated the LTRM Pool 8 catch through 2000 (Figure 4.13), but preferred- (610-709 mm TL) and memorable-sized (>710 mm TL) fish have been relatively more common since then. Interestingly, stock- and larger sized Channel Catfish numbers seem to be holding their own, even without significant contributions from the substock-size group. This would suggest that the population may be aging and mortality rates could be low. Indeed, the LTRM vital rates study has recently reported Channel Catfish in Pool 8 as old as 18 years, and mortality rates of only 20%. These suggest a slow-growing, lightly-harvested population that is likely near carrying capacity.

Figure 4.13. Catch of stock- through memorable-sized Channel Catfish annually in Navigation Pool 8

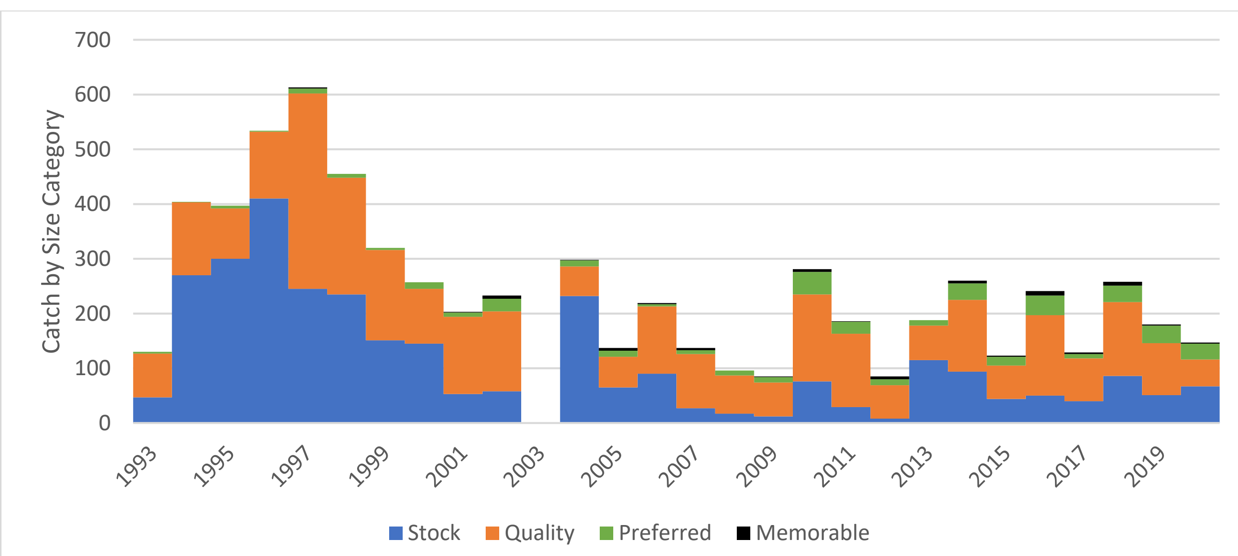


Figure 4.13. Catch of stock- through memorable-sized Channel Catfish annually in Navigation Pool 8 of the Upper Mississippi River by all gears combined from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element. Data are omitted for 2003 due to limited sampling that year.

Flathead Catfish

Total catches of Flathead Catfish from all standard LTRM gear types combined have ranged from 8 in 2006 to 100 in 1998. We caught 37 Flathead Catfish in 2020 with the reduced gear types described above. Notably, we were unable to conduct daytime electrofishing which is generally our best sampling gear for this species. CPUE from large hoop nets (Figure 4.14) declined precipitously in 2020, and slightly exceeded the long-term average. It is unknown if a decline in Flathead Catfish abundance has occurred or not. Another year of data, with all allocated gear types deployed, should help illuminate that question. Regardless, the 2020 large hoop net CPUE was still higher than most other years.

Figure 4.14. Catch per unit effort (± 1SE) of Flathead Catfish by large-hoop netting

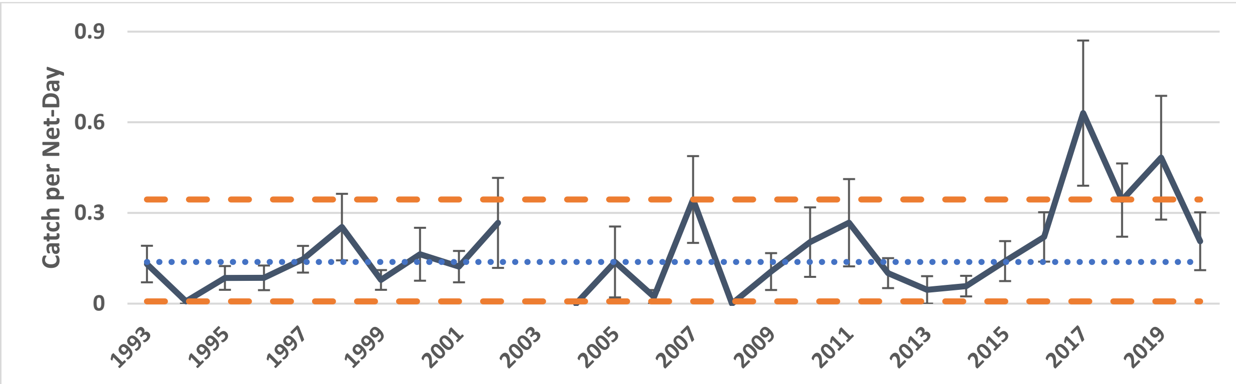


Figure 4.14. Catch per unit effort (± 1SE) of Flathead Catfish by large-hoop netting samples from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element fish collections in Navigation Pool 8 of the Upper Mississippi River. Data are omitted for 2003 due to limited sampling that year. The long-dashed lines on the CPUE graphs represent the 10th and 90th percentiles and the dotted line represents the long-term average for the period of record (1993-2020).

Catches of substock-sized (<350 mm TL) Flathead Catfish (Figure 4.15) were higher in the 1990's, then dipped, and have rebounded since 2011. We only caught a single substock Flathead Catfish in 2020 with our reduced sampling effort. Daytime electrofishing is generally our best sampling gear for those fish.

The graph of adult-sized Flathead Catfish (Figure 4.16) shows the decline in catch over the past few years from the peak in 2017. That decline in 2020 appears to be associated with all stock sizes, and, again, is consistent with the loss of samples from daytime electrofishing, a rather non-size-selective gear. All stock sizes were still represented, which suggests a healthy population.

Figure 4.15. Catch of substock-sized Flathead Catfish annually in Navigation Pool 8

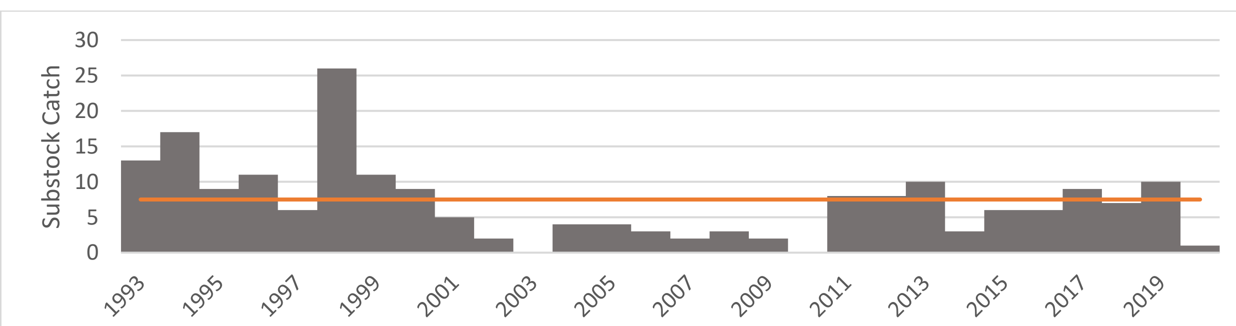


Figure 4.15. Catch of substock-sized Flathead Catfish annually in Navigation Pool 8 of the Upper Mississippi River by all gears combined from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element. The horizontal line indicates long-term average catch of substock-sized fish. Data are omitted for 2003 due to limited sampling that year.

Figure 4.16. Catch of stock- through memorable-sized Flathead Catfish annually in Navigation Pool 8

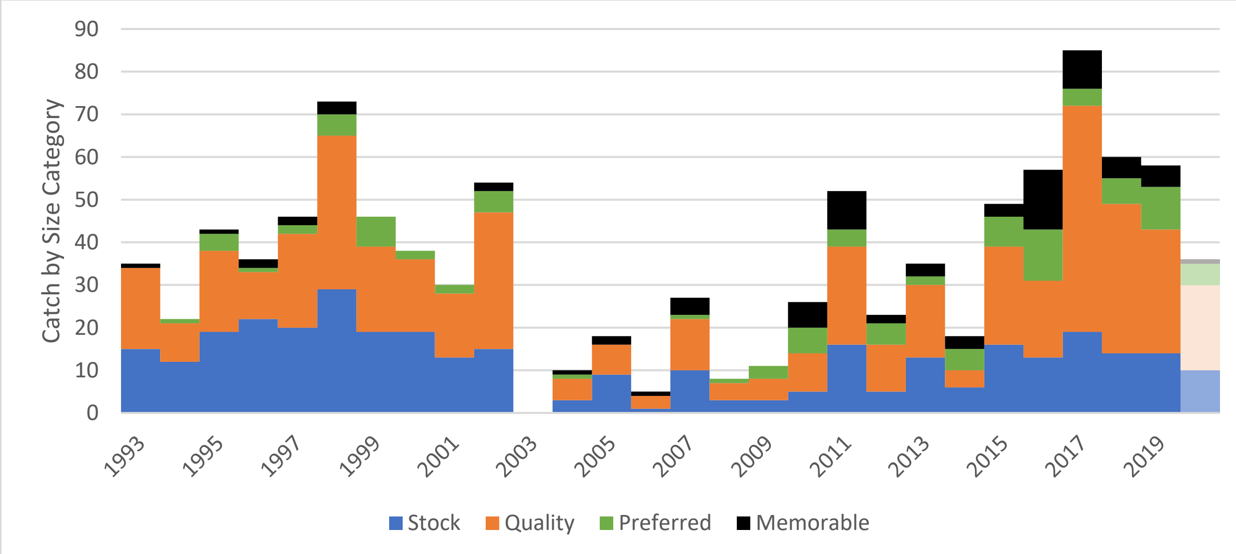


Figure 4.16. Catch of stock- through memorable-sized Flathead Catfish annually in Navigation Pool 8 of the Upper Mississippi River by all gears combined from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element. Data are omitted for 2003 due to limited sampling that year. Electrofishing and trawling data were not available for 2020, and numbers are based only on netting.

Largemouth Bass

Total catches of Largemouth Bass from all standard LTRM gear types combined have ranged from 292 in 1993 to 7,714 in 2016. We caught 377 Largemouth Bass in 2020, 369 of which were young-of-year fish in mini fyke nets. Therefore, no CPUE or stock size analysis are presented here.

Northern Pike

Total catches of Northern Pike from all standard LTRM gear types combined have ranged from 51 in 2000 to 199 in 2019. In 2020, we caught 86 Northern Pike. Fyke netting CPUE (Figure 4.17) increased again in 2020, and was just shy of the 90th percentile for the LTRM era.

Figure 4.17. Catch per unit effort (± 1SE) of Northern Pike by fyke netting

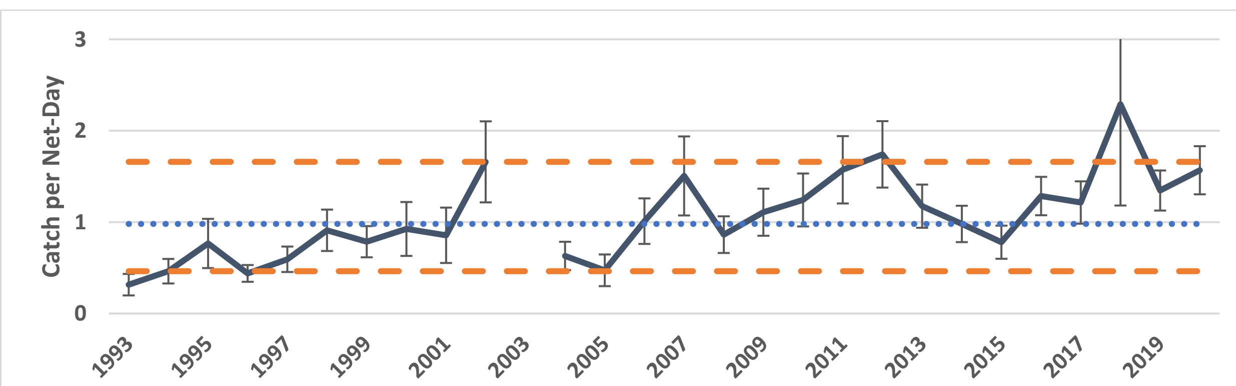


Figure 4.17. Catch per unit effort (± 1SE) of Northern Pike by fyke netting samples from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element fish collections in Navigation Pool 8 of the Upper Mississippi River. Data are omitted for 2003 due to limited sampling that year. The long-dashed lines on the CPUE graphs represent the 10th and 90th percentiles and the dotted line represents the long-term average for the period of record (1993-2020).

The catch of substock-sized (<350 mm TL) Northern Pike (Figure 4.17) was lower in 2020 than most recent years, likely due to the absence of electrofishing. However, it could also be true that the modest and relatively short spring flood produced a smaller year class in 2020. There seems to be at least some relationship (positive correlation) between the spring flood severity and year-class strength of Northern Pike.

Catches of stock-sized (350-529 mm TL) Northern Pike (Figure 4.18) also seem linked to substock catches from the previous year; whereas quality- (530-709 mm TL) and preferred- (710-859 mm TL) sizes of pike are remarkably consistent, despite reduced sampling during 2020. Thus, it would seem that recruitment and adult mortality are likely stable, and the driving factor for northern pike populations is spawning success. Memorable-sized (>860 mm TL) Northern Pike were slightly more prevalent in the first few years of SRS but are still present in most years. The LTRM graphical fish browser shows that Proportional Stock-Density for Northern Pike in Pool 8 has decreased in recent years, which consistent with a population of younger and smaller fish (Long Term Resource Monitoring Element - Graphical Fish Database Browser (usgs.gov).)

Figure 4.18. Catch of substock-sized Northern Pike annually in Navigation Pool 8

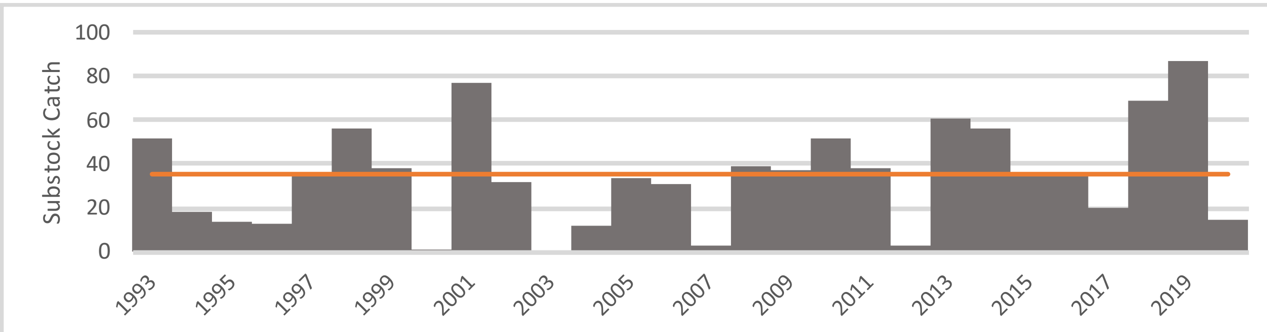


Figure 4.18. Catch of substock-sized Northern Pike annually in Navigation Pool 8 of the Upper Mississippi River by all gears combined from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element. The horizontal line indicates long-term average catch of substock-sized fish. Data are omitted for 2003 due to limited sampling that year. *2020 data limited to hoop and fyke netting.

Figure 4.19. Catch of stock- through memorable-sized Northern Pike annually

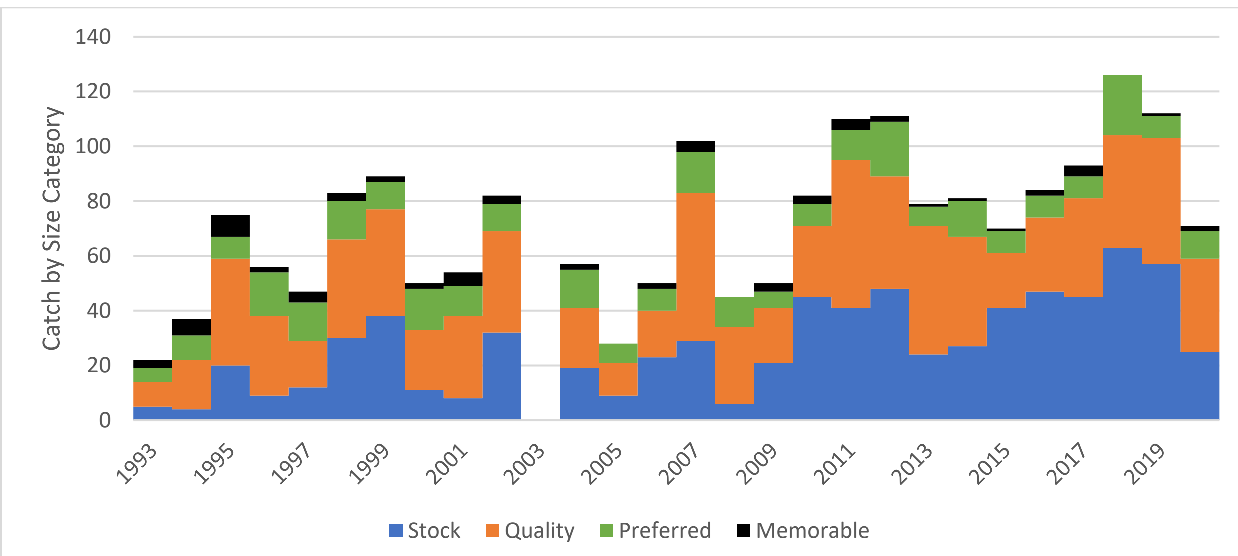


Figure 4.19. Catch of stock- through memorable-sized Northern Pike annually in Navigation Pool 8 of the Upper Mississippi River by all gears combined from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element. Catch in 2020 may be depressed due to lack of electrofishing. Data are omitted for 2003 due to limited sampling that year.

Sauger

Total catches of Sauger from all standard LTRM gear types combined have ranged from 4 in 2006 to 311 in 1998. We also caught 4 Sauger in 2020. All four of those fish were stock-sized. Due to the low numbers most likely associated with reduced sampling , no CPUE or stock size analysis are presented here.

Smallmouth Bass

Total catches of Smallmouth Bass from all standard LTRM gear types combined have ranged from 80 in 2009 to 550 in 1998. We caught 29 Smallmouth Bass in 2020, a new low catch record, but almost certainly due to the absence of electrofishing. Due to the low numbers, no CPUE or stock size analysis are presented here.

Walleye

Total catches of Walleye from all standard LTRM gear types combined have ranged from 10 in 2009 to 137 in 1997. We caught 21 Walleyes in 2020. Fyke net CPUE (Figure 4.19) increased in 2020 to near the 90th percentile. This increase is likely due to the large 2018-year class recruiting into the fyke net size range. Wide error bars indicate high variability and suggest little confidence in these low numbers.

Figure 4.20. Catch per unit effort (± 1SE) of Walleye by fyke netting

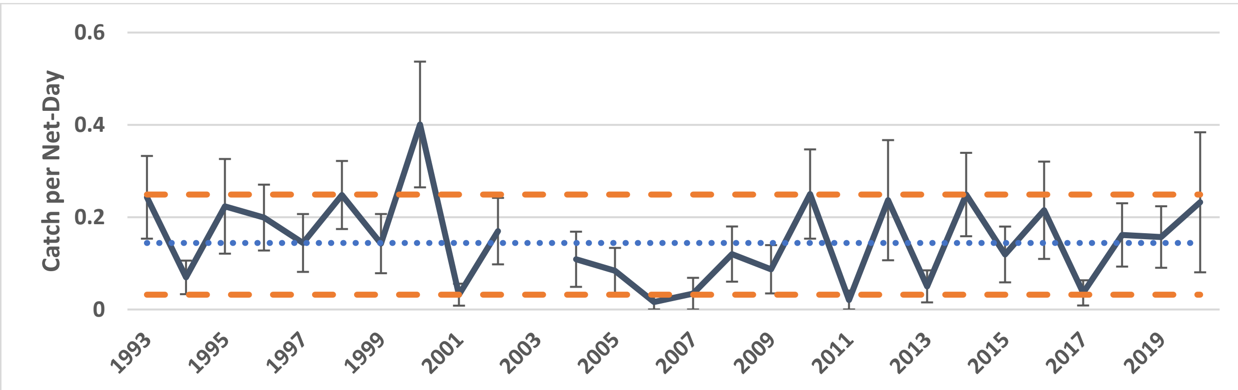


Figure 4.20. Catch per unit effort (± 1SE) of Walleye by fyke netting samples from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element fish collections in Navigation Pool 8 of the Upper Mississippi River. Data are omitted for 2003 due to limited sampling that year. The long-dashed lines on the CPUE graphs represent the 10th and 90th percentiles and the dotted line represents the long-term average for the period of record (1993-2020).

DNR caught 10 substock-sized Walleyes in 2020 (Figure 4.20), with no electrofishing done; this suggests that at least a moderate hatch occurred. These recent consecutive years of production may spell good news for the long-declined population.

Figure 4.21. Catch of substock-sized Walleye annually in Navigation Pool 8

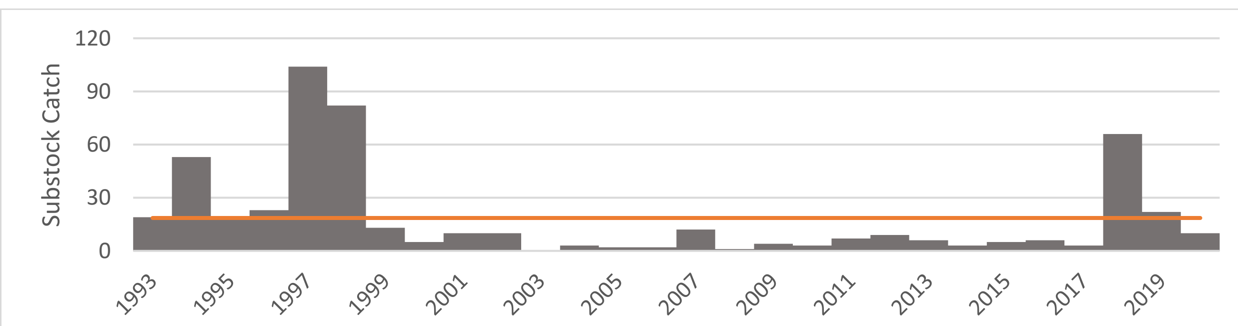


Figure 4.21. Catch of substock-sized Walleye annually in Navigation Pool 8 of the Upper Mississippi River by all gears combined from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element. The horizontal line indicates long-term average catch of substock-sized fish. Data are omitted for 2003 due to limited sampling that year.

Eight stock-sized (250-379 mm TL) Walleyes were caught in 2020 (Figure 4.21), suggesting some recruitment of recent hatchlings to adulthood. Beyond that size, however, only three fish were caught, rendering any further interpretation impossible. Successful recruitment is a positive step toward population recovery.

Figure 4.22. Catch of stock- through memorable-sized Walleye annually in Navigation Pool 8

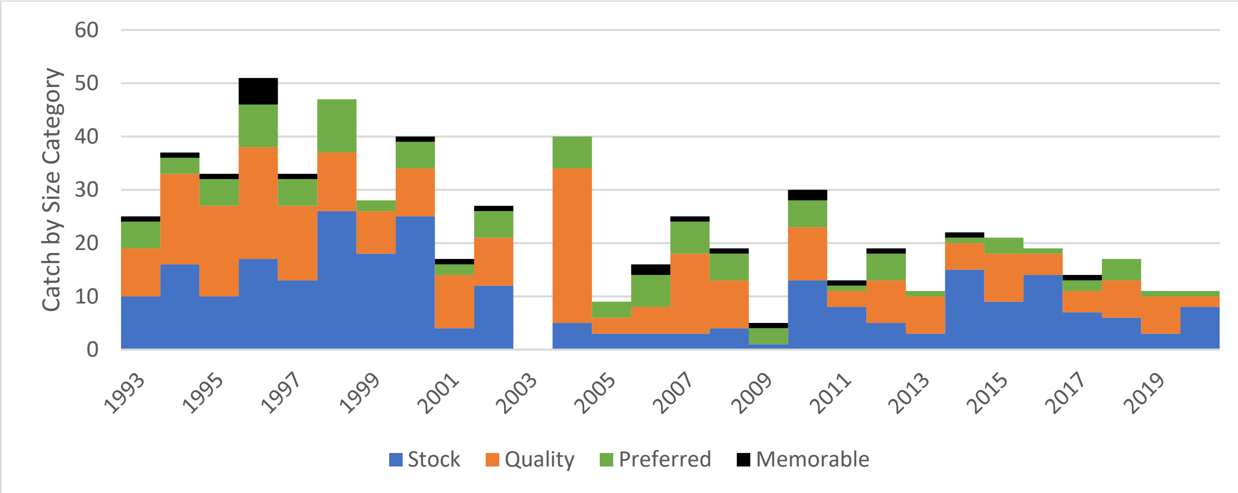


Figure 4.22. Catch of stock- through memorable-sized Walleye annually in Navigation Pool 8 of the Upper Mississippi River by all gears combined from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element. Data are omitted for 2003 due to limited sampling that year.

Yellow Perch

Total catches of Yellow Perch from all standard LTRM gear types combined have ranged from 53 in 2000 to 1,579 in 2015. We caught 391 Yellow Perch in 2020. Fyke net CPUE for Yellow Perch (Figure 4.22) increased for the fourth straight year in 2020, approximating the 75th percentile for the period of record.

Figure 4.23. Catch per unit effort (± 1SE) of Yellow Perch by daytime electrofishing (top graph) and fyke netting (bottom graph)

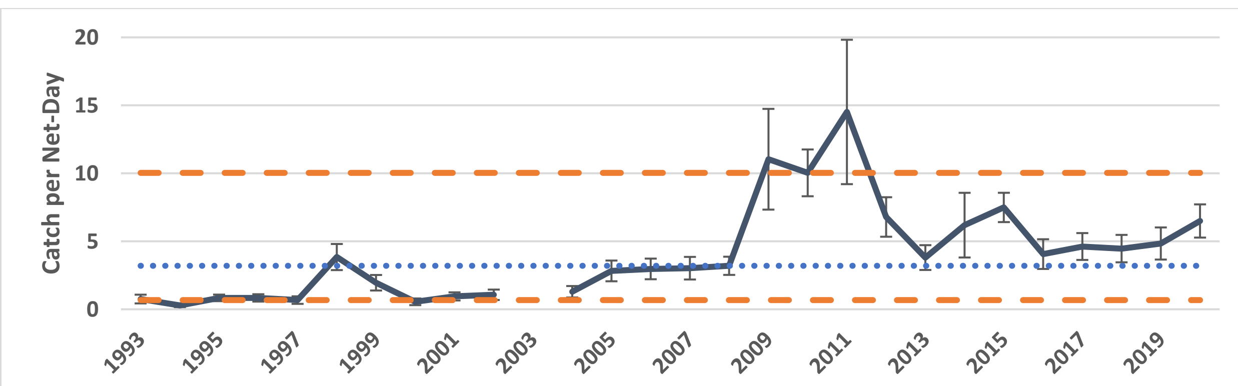


Figure 4.23. Catch per unit effort (± 1SE) of Yellow Perch by daytime electrofishing (top graph) and fyke netting (bottom graph) samples from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element fish collections in Navigation Pool 8 of the Upper Mississippi River. Data are omitted for 2003 due to limited sampling that year. The long-dashed lines on the CPUE graphs represent the 10th and 90th percentiles and the dotted line represents the long-term average for the period of record (1993-2020).

Omitted electrofishing samples resulted in poor numbers of substock-sized (<130 mm TL) Yellow Perch (Figure 4.23). Still, 59 juveniles were collected, indicating that a hatch occurred.

Figure 4.24. Catch of substock-sized Yellow Perch annually in Navigation Pool 8

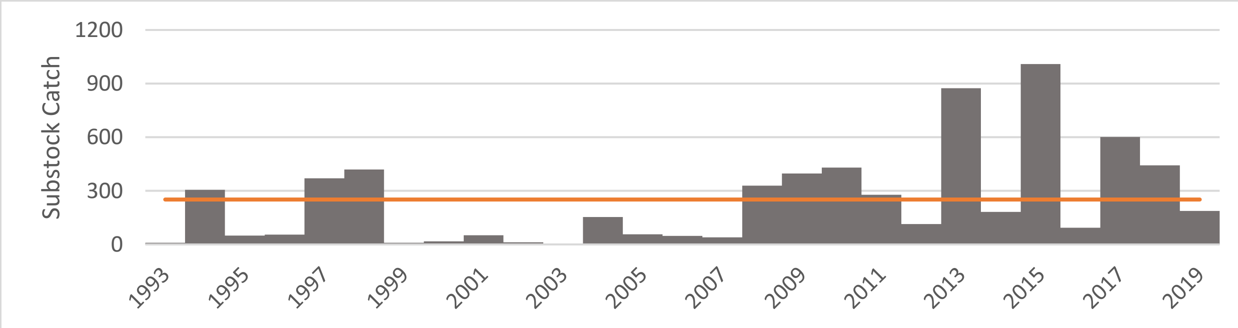


Figure 4.24. Catch of substock-sized Yellow Perch annually in Navigation Pool 8 of the Upper Mississippi River by all gears combined from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element. The horizontal line indicates long-term average catch of substock-sized fish. Data are omitted for 2003 due to limited sampling that year.

All sizes of adult perch were caught in 2020 (Figure 4.24), and numbers of quality-, preferred-, and memorable-sized fish appeared similar to other recent years where full sampling complements were completed. Thus, it seems that the population of older fish is stable. An apparent long-term decline in stock-sized Yellow Perch will need to be evaluated once normal sampling effort resumes.

Figure 4.25. Catch of stock- through memorable-sized Yellow Perch annually

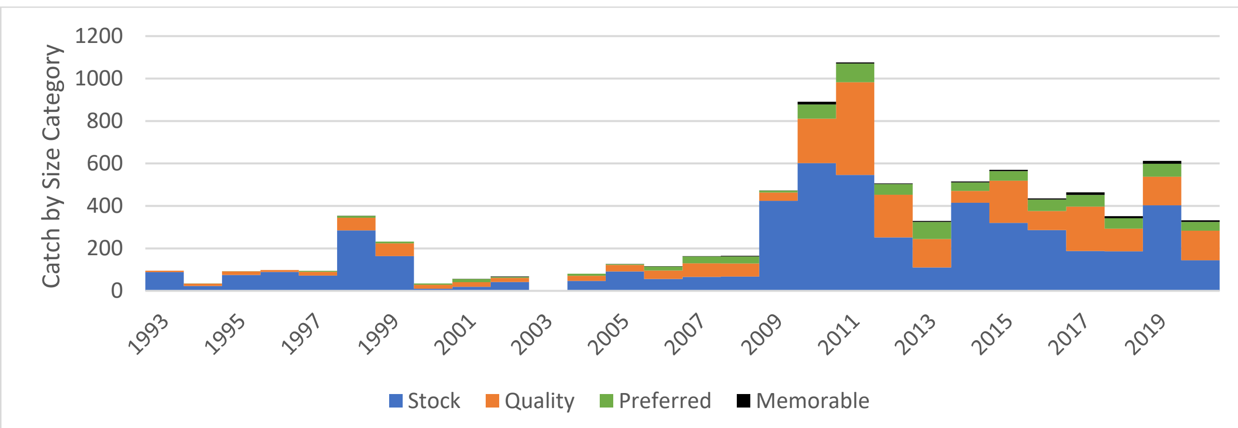


Figure 4.25. Catch of stock- through memorable-sized Yellow Perch annually in Navigation Pool 8 of the Upper Mississippi River by all gears combined from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element. Data are omitted for 2003 due to limited sampling that year.

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