

Upper Mississippi River Pool 8 Long-Term Resource Monitoring Year 2023 Status Report

Wisconsin DNR Office of Great Waters, Mississippi River Field Station 2
EGAD #3900-2024-05



About this Report

Purpose

This status report describes the results of monitoring in 2023 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 implemented 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 management.

Acknowledgements

Andrew Bartels – Co-Author and Fisheries Specialist, Wisconsin DNR
Alicia Carhart – Co-Author and Vegetation Specialist, Wisconsin DNR
John Kalas – Co-Author and Water Quality Specialist, Wisconsin DNR
Patrick Kelly – Document Reviewer and Mississippi River Team Leader, Wisconsin DNR
Ben Patschull – Document Reviewer and Field Operations Specialist, Wisconsin DNR
Cadie Olson – Document Reviewer and Macroinvertebrate Specialist, Wisconsin DNR
Jeremy King – Document Reviewer and Water Quality Technician, Wisconsin DNR
Stephanie Szura – Document Reviewer and Vegetation Technician, Wisconsin DNR
Bonnie Richards – Document Reviewer and Fisheries Technician, Wisconsin DNR

For More Information

LTRM website: [Long Term Resource Monitoring - Environmental Management Program \(LTRM-EMP\) \(usgs.gov\)](https://www.usgs.gov/programs/ltrm)

UMRR website: [Upper Mississippi River Restoration \(UMRR\) Program](https://www.usgs.gov/programs/umrr)

WDNR Documents Online: [Electronic Guidance and Documents \(EGAD\) \(wi.gov\)](https://dnr.wisconsin.gov/EGAD)

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Wisconsin Department of Natural Resources

101 S. Webster Street • PO Box 7921 •

Madison, Wisconsin 53707-7921 608-266-2621



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Executive Summary

This report summarizes the annual increment of monitoring accomplished in 2023 by the Wisconsin Department of Natural Resources' La Crosse Field Station for the Long-Term Resource Monitoring (LTRM) Element of the Upper Mississippi River Restoration Program. This document provides data, observations, and analyses of Navigation Pool 8 of the Upper Mississippi River System (UMRS), emphasizing 2023 sampling year in the context of historic data and trends. For more information on conditions and trends occurring throughout the UMRS, [Ecological Status and Trends of the Upper Mississippi and Illinois Rivers](#) is a valuable resource that identifies statistically significant trends in ecological conditions of the UMRS observed from nearly three decades of monitoring. It includes information on water quality, aquatic vegetation, and fisheries data from six study areas (including Pool 8) as well as select system-wide data and analyses for possible drivers of UMRS ecological dynamics, including hydrology, geomorphology, and land cover.

In Pool 8, the 2023 mean annual discharge was near the long-term average and the growing season (May-September) mean daily discharge was just below the long-term average for the LTRM period of record (POR). This marked a substantial change from the persistent high-water conditions that characterized the growing seasons of the last decade and is the fourth consecutive year breaking the high growing season discharge trend.

Quarterly water quality monitoring in 2023 [winter (January), spring (April-May), summer (July-August) and fall (October)] indicated anomalous values for several variables. Spring median water temperature was the second lowest for the LTRM POR (7.63°C). The LTRM SRS data show spring water temperatures decreasing, which is surprising, as average air temperatures have been rising. Total phosphorous (TP) and total nitrogen (TN) concentrations were at or below the long-term median for all sampling periods during 2023, except TP in spring; summer and fall TN and summer TP were second lowest for the LTRM POR. This may be a sign of progress in nutrient reduction efforts being implemented in the watershed. The LTRM SRS data show decreasing trends for summer, fall and winter TP, and summer TN; winter data shows an increasing trend for TN. Fall had the second lowest total suspended solids (TSS) for the POR (2.07 mg/l). The LTRM SRS data show decreasing trends for spring, summer and fall TSS; decreases in common carp biomass and increases in aquatic vegetation likely played a role in these observed long-term declines.

Pool-wide prevalence of aquatic vegetation was near the highest reported for LTRM POR. The most common submersed species recorded in 2023 were coontail, Canadian waterweed, small pondweed, water stargrass, and wild celery. Prevalence of rooted floating-leaf species remained high with American lotus, white water lilies, and/or yellow pond lilies present at 60% of contiguous backwater sites. A particularly high abundance of wild rice was observed in 2023 (detected at 37% of sites), which set a new high record for pool-wide prevalence in Pool 8. Invasive flowering rush was encountered more frequently in 2023 and was often observed growing with various native species but occasionally formed dense monocultures. LTRM vegetation field crews are working closely with US Fish and Wildlife Service to assess changes in percent cover of flowering rush following herbicide treatment.

Fish catch rates, species richness, and Shannon Weiner Diversity Index scores were low in 2023, compared to recent years. The 2023 water year contained a sharp contrast between extreme high-water levels in the spring and very low water during most of the sampling season, which may have influenced the fish community. Many of the usual suspects (Bluegill, Largemouth Bass, and Weed Shiner) dominated the catch, while Common Carp, Bowfin, and Shorthead Redhorse remained the top contributors by weight. The number of species that can be roughly classified as abundant, common, uncommon, and rare remained stable, and the usual state-listed species were encountered with similar frequency as in previous years, except for Lake Sturgeon, which seem to be increasing. Also, a Pallid Shiner was caught for only the third time in Pool 8 during the LTRM era. Pool 8 is very healthy in regard to invasive fishes, as Common Carp remain the only established invader, and they have declined consistently to numbers far lower than in previous times. While most species of recreationally-harvested fish seem to be thriving in Pool 8, long-term declines have been observed for both Black Crappie and Sauger. In both cases, lack of small fish entering the population seems to be the likely cause.

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Climate and Hydrograph 2023

Methods

Climate data were acquired from the National Weather Service's (NWS) website for La Crosse, Wisconsin (source: NWS, <https://www.weather.gov/arx/lse2023>). Herein, we report simple summaries of local temperature and precipitation patterns for the year.

For hydrographic analyses, we acquired discharge estimates from the U.S. Army Corps of Engineers, St. Paul district water reports website ([Water Management Reports \(army.mil\)](https://watermanagementreports.army.mil)) at Lock and Dam 8 at Genoa, WI. This outflow location at the downstream end of Pool 8 represents both mainstem flow, as well as important local tributary flow inputs. The dataset includes discharge values collected at 1200 hours daily, for all years from 1959 through 2023, and recorded in cubic feet per second (cfs).

A historical hydrograph was constructed by computing the mean daily discharge values from the years 1959-2022. The daily discharge for 2023 was then overlain on the long-term daily mean to observe departure from typical conditions (Figure 1.1a). Additional analyses examined annual, growing season (May–September), and spring flood discharge characteristics. Mean annual discharge was calculated from daily values, plotted for years 1993-2023 (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 2023) (Figure 1.1b). Mean growing season discharge was calculated and plotted similarly to the mean annual discharge (Figure 1.1c). 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

The National Weather Service reported that 2023 was the 4th warmest year on record in La Crosse, with an annual average temperature of 51 degrees F. High temperatures reached or exceeded 90 degrees F 30 times and new records were set on 6 days. Low temperatures only fell below zero 5 times and no record low temperatures occurred. All months except July exhibited above normal temperatures.

Total precipitation in 2023 was less than 30", which is ~7.5" below normal. However, precipitation was highly variable throughout the year which led to extended periods of flooding as well as drought. The year started off very wet - February and March were among the ten wettest on record. The above normal precipitation, along with late season snow melt, resulted in the 3rd highest flood on record in La Crosse (Figure 1.1a). Drought conditions developed quickly in April and continued to build throughout the summer. The local area experienced "severe" drought for several months, something that was last observed in the early 2000s.

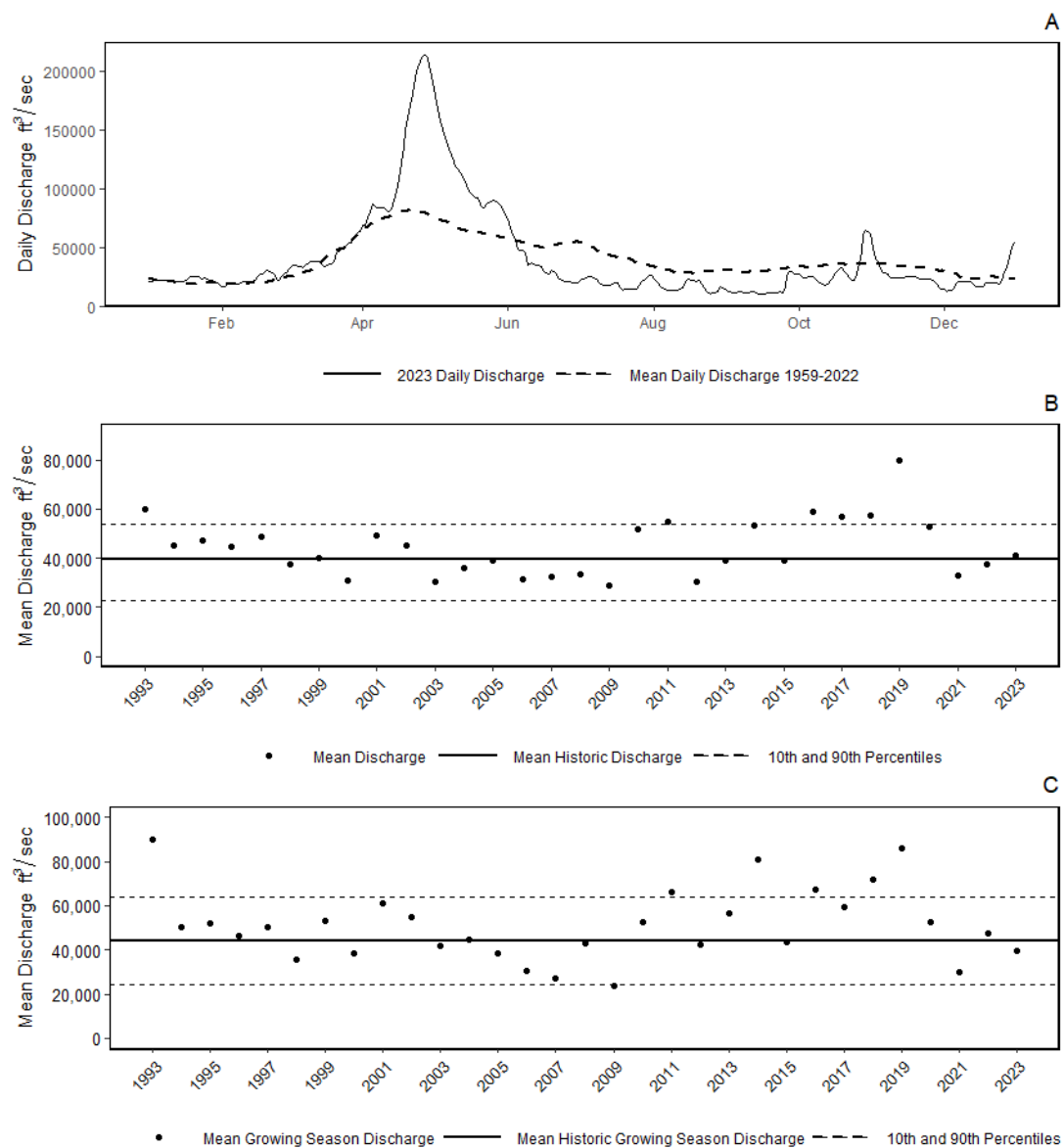
Figure 1.1 Year 2023 hydrograph at Lock and Dam 8

Figure 1.1. (A) Daily discharge at Lock and Dam 8 on the Upper Mississippi River for 2023 is represented by the solid line. Mean daily discharge by day of the year for 1959-2022 is represented by the dotted line. (B) Mean discharge by year is represented by the black dots. The solid line represents mean historic discharge for 1959-2023. The dashed lines represent the 10th and 90th percentiles for 1959-2023 discharge. (C) Mean growing season discharge (May-Sept.) by year is represented by the black dots. The solid line represents mean historic growing season discharge for 1959-2023. The dashed lines represent the 10th and 90th percentiles for 1959-2023 growing seasons.

Our spring flood analysis (Table 1.1) shows that the high-water peak occurred in April, on cue with snowmelt, and was of high magnitude (214,000 cfs) and long duration (57 days).

Table 1.1. Spring flood pulse statistics by year during the LTRM period of record (1993-2023) 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 (1959-2023). 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 recorded in cubic feet per second (cfs).

Table 1.1 Spring flood pulse statistics by year during the LTRM period of record (1993-2023)

Year	Duration	Timing	Magnitude	Year	Duration	Timing	Magnitude
1993	56	April	116100	2009	11	April	83700
1994	20	May	106000	2010	26	March	114200
1995	27	May	85400	2011	67	April	168000
1996	29	April	137800	2012	0	May	77500
1997	40	April	188500	2013	50	May	116100
1998	22	April	122200	2014	49	May	133300
1999	32	May	110500	2015	1	May	78900
2000	0	March	66600	2016	14	March	105500
2001	54	April	224700	2017	50	May	128900
2002	18	April	119900	2018	25	May	134700
2003	23	May	116900	2019	77	April	175400
2004	3	April	81400	2020	43	April	132300
2005	19	April	96100	2021	2	April	80200
2006	24	April	103800	2022	47	May	104900
2007	18	April	87500	2023	57	April	214000
2008	40	May	100300				

Large temperature fluctuations in February and March gave way to warm temperatures in April, which recorded two record high air temperatures. The growing season yielded above average temperatures and below average precipitation. The hydrograph reflected these conditions and depicted below normal flow from June through October, which made site access more challenging but did not preclude any sampling allocations from being accomplished. Both the growing season mean daily discharge (Figure 1.1c) and the annual mean daily discharge (Figure 1.1b) were very close to historic means.

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 every two weeks 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: <https://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 2023 were near the long-term median for winter and fall, near the 75th percentile in summer and below the 10th percentile for spring, (Figure 2.1A). Median water temperature for spring was 7.81 °C, the second lowest in the LTRM POR, likely delaying aquatic vegetation growth and impacting fish spawning success. Water temperature can have direct and indirect effects on large river ecology. Warm water temperatures can result in higher respiration rates 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 2.1 A-F Box plots represent the 10th, 25th, 50th, 75th, and 90th percentiles of the medians by stratified random sampling season

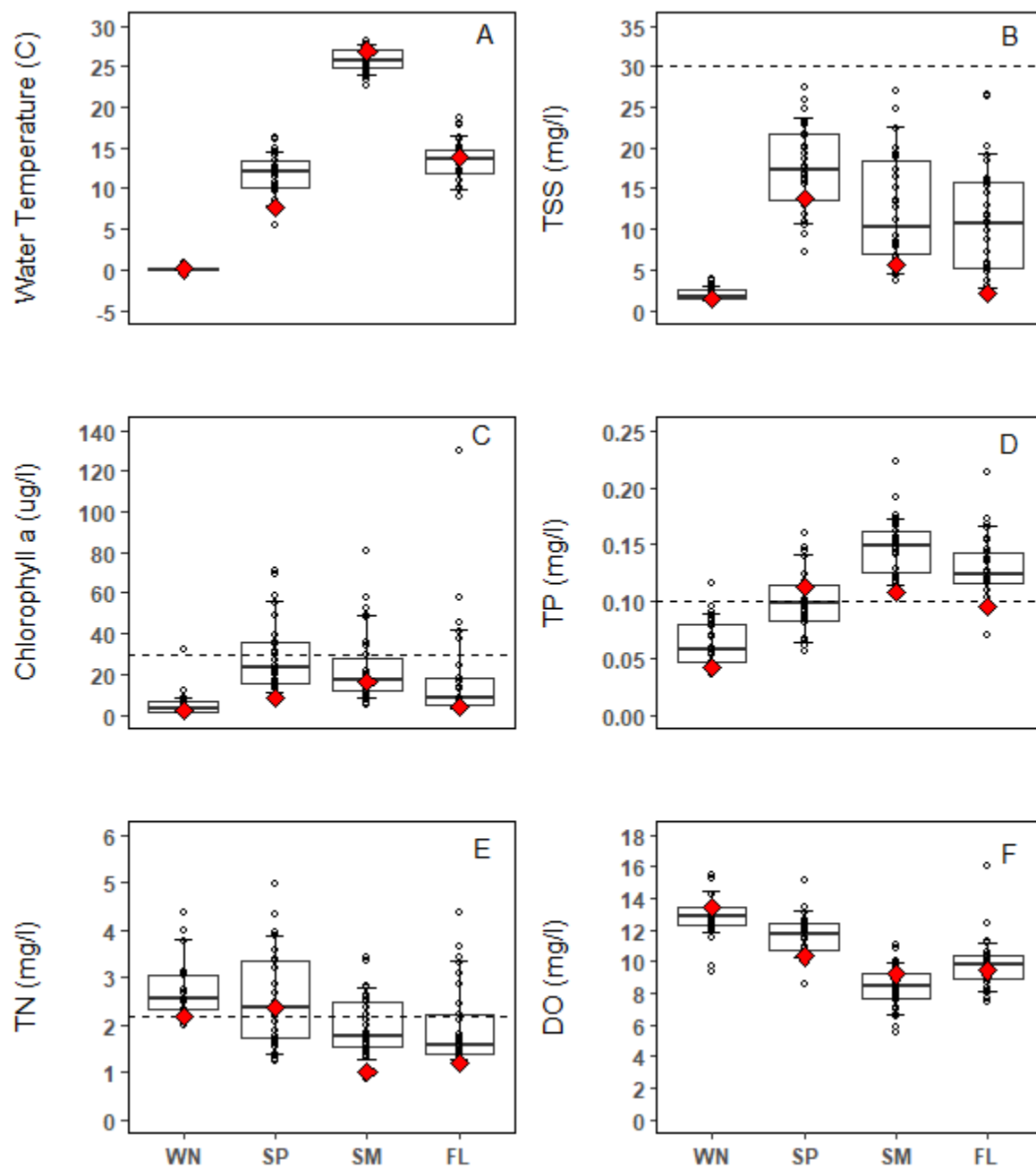


Figure 2.1A-F Box plots represent the 10th, 25th, 50th, 75th, and 90th percentiles of the medians by stratified random sampling season (WN – winter, SP – spring, SM – summer, FL – fall) for the Long-Term Resource Monitoring period of record (1993-2023). The diamonds represent the weighted pool-wide median for each parameter by season for 2023. The dashed line represents: (B) the upper total suspended solids (TSS) 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 (TP) criterion for non-wadeable

rivers in Wisconsin as defined by NR 102.06; (E) the upper limit of the range suggested for total nitrogen (TN) as defined by the USEPA, 2000.

The LTRM SRS data show a significant trend in pool scale median spring water temperature over the period of record (1993-2023, figure 2.2); this also shows the wide range of variability in environmental conditions biota must endure on an annual basis and may reflect the predicted extreme conditions that climate change can impose on systems. While spring of 2023 was an anomalous year in terms of colder water temperatures, the long-term decreasing temperatures during spring is surprising, considering an average increase in spring air temperature of approximately 3°F observed in Wisconsin between 1950-2018 (<https://wicci.wisc.edu/wisconsin-climate-trends-and-projections/>).

Figure 2.2 Pool wide temperature in Pool 8 during Spring

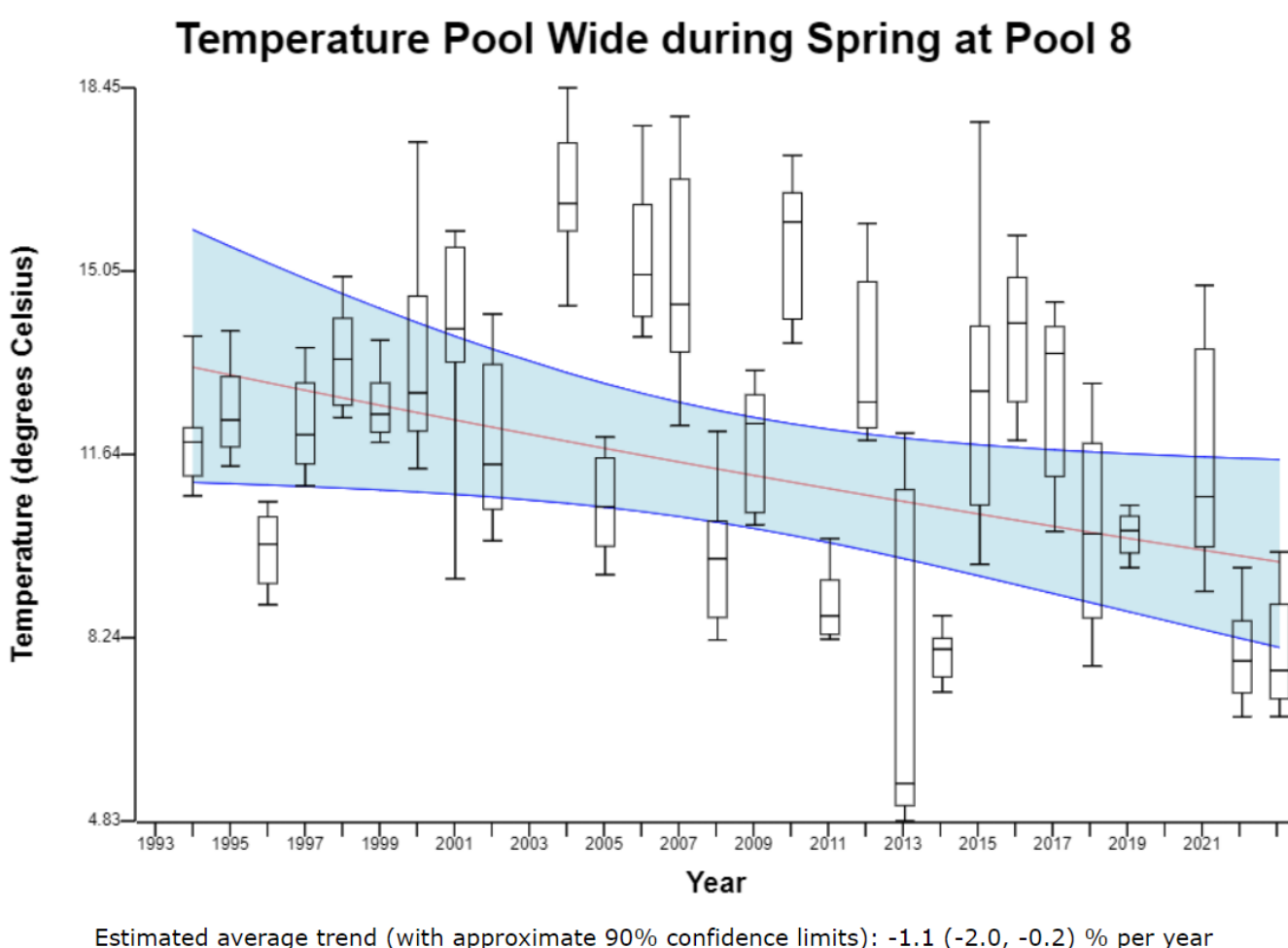


Figure 2.2. Declining spring water temperature is suggested by the long-term monitoring data; 2023 had the second lowest median temperature for the POR. This figure was produced by the LTRM graphical browser at: http://www.umesc.usgs.gov/data_library/water_quality/water_quality_page.html.

Constituents

Total suspended solids (TSS) concentrations were near the 25th percentile in winter and spring, below the 25th percentile in summer, and below the 10th percentile in fall (Figure 2.1B). Fall 2023 had the second lowest median

TSS values (2.07 mg/l) for the LTRM period of record (1993-2023). The LTRM SRS Pool 8 trend data show decreasing trends in pool-wide TSS for spring, summer, and fall. Over the past two decades, 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 2023 were near the median in summer, near the 25th percentile in winter and fall, and below the 10th percentile for spring, (Figure 2.1C). The LTRM SRS trend data show a decreasing trend in fall. Median chlorophyll a concentrations during all seasons were well below the eutrophic range for rivers (>30 µg/L, Dodds et al., 1998), which is typical.

Total phosphorous (TP) concentrations in 2023 were near or below the 10th percentile for winter, summer and fall, and near the 75th percentile for spring, (Figure 2.2D). The LTRM SRS trend data (pool-wide medians 1993-2023) show decreasing trends in winter, summer and fall. 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 data doesn't allow direct comparison, TP concentrations were running very close to the impairment level in fall, while spring and summer were above the 0.10 mg/L level.

Total nitrogen (TN) concentrations in 2023 were near or below the 10th percentile in winter, summer and fall, and near the median during spring, (Figure 2.2E). In 2023, spring was the only season where median TN exceeded the maximum concentration of 2.18 mg/L recommended by the USEPA for ecosystem health (USEPA, 2000). Trends for TN are mixed, the LTRM SRS trend data (pool-wide medians 1993-2023) show an increasing trend in winter and decreasing trend in summer.

Constituents-mechanisms and synthesis

Important indicators of water quality suggest substantial improvement over the period of LTRM monitoring in Pool 8 (Houser, 2022). This includes long-term increase in water clarity, long-term decrease in TP in all seasons, long-term decrease in summer TN and NO₃-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 NO₃-N, which have increased steadily over the LTRM period of record. Observations in 2023 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 program. 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 Aquatic Vegetation section), creates additional areas suitable for its establishment by trapping TSS, attenuating waves, reducing water velocity, erosion, and wind resuspension. Decreases in common carp biomass and increases in aquatic vegetation likely played a role in the observed long-term declines in TSS (Houser, 2022; Carhart et al. 2024). 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. Both TSS and TP concentrations can be driven by discharge. The low discharge in 2023 (winter, summer, and fall) likely played a role in the very low concentrations observed for TP and TSS.

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 generally doesn't limit phytoplankton production in much of Pool 8, the frequent and erratic spikes in discharge commonly observed in Pool 8 may explain the relatively low chlorophyll a concentration (typically below the lower limit of the eutrophic range) 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, the low chlorophyll levels in summer were surprising because low discharge coupled with high water temperatures have been found to be important drivers of abundance and toxicity of harmful algal blooms (Giblin and Gerrish 2020). 2023 might be a

rare year where nutrients were limited during summer (TP and TN were both below the 10th percentile). LTRM researchers are currently analyzing archived phytoplankton samples which should improve our understanding of phytoplankton dynamics.

2023 is the 4th consecutive year experiencing some of the lowest median TP observations in the LTRM period of record. TN has also been relatively low in spring, summer and fall; this may be a sign of progress in nutrient reduction efforts being implemented in the watershed. However, 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://www.pca.state.mn.us/water/nitrogen>).

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 through diffusion and turbulence, and water movements depending on discharge and currents. In 2023, DO was near the 75th percentile in winter and summer, near the 10th percentile in spring and near the 40th percentile in and fall, (Figure 2.2F). The LTRM SRS trend data (pool-wide medians 1993-2023) does not show any significant trends for DO in any season. DO concentrations exceeded the level of concern for fish and invertebrates (~5 mg/L) at more than 90% of sites. Hypoxic/anoxic conditions were measured at only ~5% of sites for the year. However, our sampling is during the daytime (centering on noon), so it does not give us information on diurnal swings of DO.

Snow and Ice

Median ice and snow thickness in 2023 were near or below 25th percentile (Figure 2.3). The LTRM SRS pool-wide data (1993-2023) does not show any significant trends for ice or snow thickness. In winter, ice and snow cover can affect the concentration of DO in the underlying water column by regulating light transmission (and therefore photosynthesis) and preventing gas exchange with the atmosphere. Long periods of snowpack on top of ice often leads to low DO concentrations (<5 mg/L). High under-ice DO suggest photosynthetic activity by phytoplankton or overwintering aquatic macrophytes.

Oxygen supersaturation, likely a result 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 in the UMR. The decreased ice and snow thickness in winter 2023 likely resulted in the higher observed DO. Even with the thinner ice and snow cover, we had very few sites with supersaturated DO, most were less than 110% saturation, 141% saturation was the highest we observed.

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

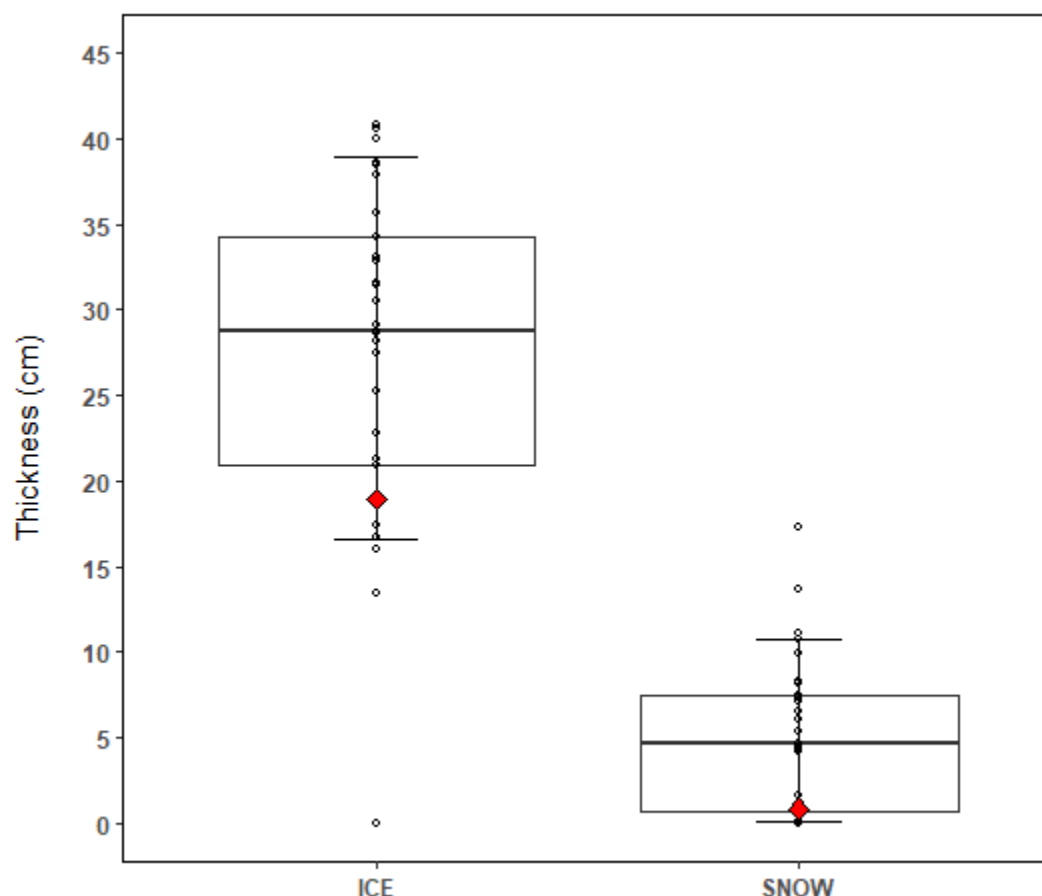


Figure 2.3. Box plots represent the 10th, 25th, 50th, 75th, and 90th percentiles of the medians by stratified random sampling during winter for the Long-Term Resource Monitoring period of record (1993-2023). The diamonds represent the weighted pool-wide median for each parameter for winter SRS 2023.

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 (*i.e.*, stratified random sampling; SRS).

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. Submersed aquatic vegetation 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). Filamentous algae on the rake is scored separately using the same scoring scheme. Water depth at the time of sampling and substrate type are also recorded at each vegetation site. In addition, vegetation crews began measuring water velocity at all sites in 2022.

Pool 8 aquatic vegetation trends are based on data spanning 1998 – 2023, and data were downloaded from the LTRM graphical data browser at: https://www.umesc.usgs.gov/data_library/vegetation/graphical/veg_front.html

Results

Despite below average discharge throughout most of the sampling period (Figure 1.1a), we were able to survey 448 out of the 450 scheduled sites between 15 June and 10 August in 2023; only two sites were inaccessible. The number of walk-in sites increased again in 2023 (N=45, 10% of sites), likely a factor of low water levels and changing geomorphology.

A total of 48 aquatic plant species were recorded in 2023 including filamentous algae and duckweed species. Typically, between 4 and 8 species were detected at vegetated sites. The maximum number of species found at a single site in 2023 was 20, which set a new record for Pool 8 (previous high record was 18 species). 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). In 2023, emergent and submersed vegetation co-occurred at 41-percent of sites, which can create substantial vegetation structure, biomass, and diversity.

Pool-wide detection rates of aquatic vegetation were near the highest reported for LTRM period of record (POR). The vegetation field crew noted a visibly high abundance of wild rice (*Zizania aquatica*), especially in the lower half of Pool 8. The invasive flowering rush (*Butomus umbellatus*) was encountered more frequently in 2023 and was often observed growing with various native species, especially wild rice, although occasionally formed dense monocultures. Additionally, the invasive brittle naiad (*Najas minor*) was observed for the 3rd consecutive year in Pool 8 in 2023.

Patterns in aquatic vegetation by LTRM stratum

Vegetation abundance varied considerably among strata, with slow-moving and still waters (backwater isolated, backwater contiguous, and impounded strata) generally supporting more aquatic vegetation than swift waters (side channels and main channel borders; Table 3.1; Figure 3.1). Average depths in contiguous backwaters at the time of sampling in 2023 were, on average, ~41 cm shallower than the long-term average depth for this stratum (1998-2022).

Table 3.1. Summary of site distribution among strata for aquatic vegetation sampling in 2023. 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 2023

Stratum	Number of sites	2023 mean depth m (SD)	2023 % Vegetated
Backwater connected (BWC)	108	0.45 (0.49)	94.4%
Backwater isolated (BWI)	20	0.29 (0.25)	100 %
Impounded (IMP)	185	1.27 (0.61)	91.4%
Main channel border (MCB)	70	1.76 (1.28)	32.9%
Side channel (SC)	65	1.24 (0.99)	56.9%

Figure 3.1 Prevalence of life forms by stratum in 2023

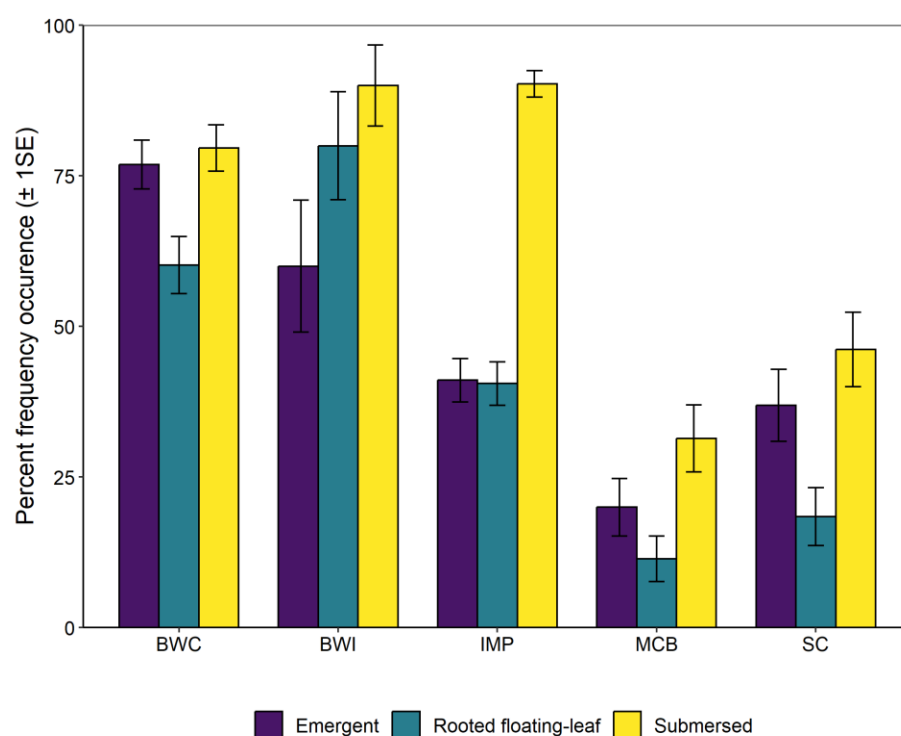


Figure 3.1. Prevalence (± 1 SE) of life forms by stratum in 2023.

Long-term patterns in vegetation abundance

Since LTRM vegetation SRS 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 3.2). Primary causes of increased aquatic vegetation abundance and diversity are not yet well understood, but likely include multiple abiotic and biotic factors such as increased water clarity, reduced wind fetch from HREPs, reduced bioturbation from common carp, and decreased nutrient loading (Houser, 2022; Carhart et al., 2024).

The prevalence of submersed species increased slightly from 70% in 2022 to 72% in 2023 (Figure 3.2). Field crews observed extremely robust growth and flowering of rooted floating-leaf species in backwater habitats of Pool 8 in 2023. The pool-wide prevalence of rooted floating-leaf species increased slightly in 2023 (Figure 3.2) and was the 2nd highest in the LTRM POR (present at 39.3% of sites). The fluctuations observed in the prevalence of rooted floating-leaf species may be associated with discharge, where prevalence decreases during years with high growing season discharge and increases during years with low growing season discharge.

Figure 3.2 Pool-wide prevalence of the three vegetation life forms over 26 years of probabilistic monitoring (± 1 SE)

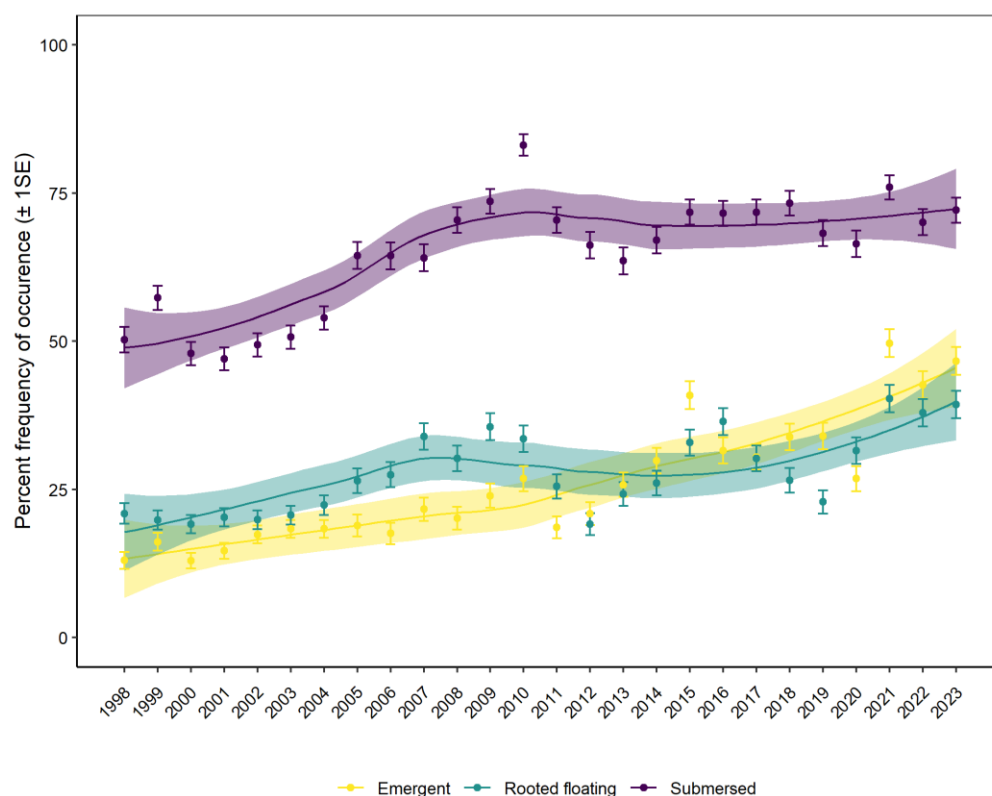


Figure 3.2. Pool-wide prevalence of the three vegetation life forms over 26 years of probabilistic monitoring (± 1 SE). Locally weighted regression (LOESS model) trendlines (solid lines) and 95% confidence intervals (shaded areas) depict temporal patterns over the period of 1998-2023.

The prevalence of emergent species has generally increased over the POR (Figure 3.2), although the species driving this increase have shifted from broadleaf and stiff arrowhead (*Sagittaria latifolia* and *S. rigida*, respectively) which increased between 1998 and ~2010 to wild rice (*Zizania aquatica* L.) which expanded considerably beginning in the mid-2000s (Figure 3.3). Carhart et al. 2023 found that arrowhead abundance was highly variable annually and was associated with lower growing season discharge, water depth, water velocity, and wind fetch compared to wild rice.

A considerable portion of the increase in aquatic vegetation over the LTRM POR 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 canvasbacks (*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 3.3). Wild celery in the impounded stratum of Pool 8 is currently ~6x more prevalent than it was in 1998-2001. The detection rate declined steadily from 2016-2020 and may have been influenced by periods of high

discharge and deeper water. In 2023, wild celery was detected at 68% of impounded sites (~39% pool-wide, Figure 3.3), falling just short of the 2021 record.

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 only 1-3% of sites annually between 1998 and 2008, but expanded rapidly between the mid-2000s and 2019. High detection 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. In 2020, prevalence decreased sharply to only 10% of sites; however, wild rice has since rebounded, and in 2023 the highest pool-wide prevalence on record was reported (37.1%; Figure 3.3). Interestingly, prior to 2021-2023, the highest frequencies of wild rice were observed in the years of highest growing season discharge and depth. Wild rice appears to be able to flourish in high and low water years and remains the most frequently detected emergent species in Pool 8 LTRM surveys. Carhart et al. 2023 found that wild rice initially occupied high diversity, shallow backwater habitats in 1998, however, over time this species expanded to deeper, lotic areas.

Figure 3.3 Trends in the pool-wide detection of wild celery, wild rice, and arrowheads in Pool 8 over the period of LTRM vegetation SRS monitoring

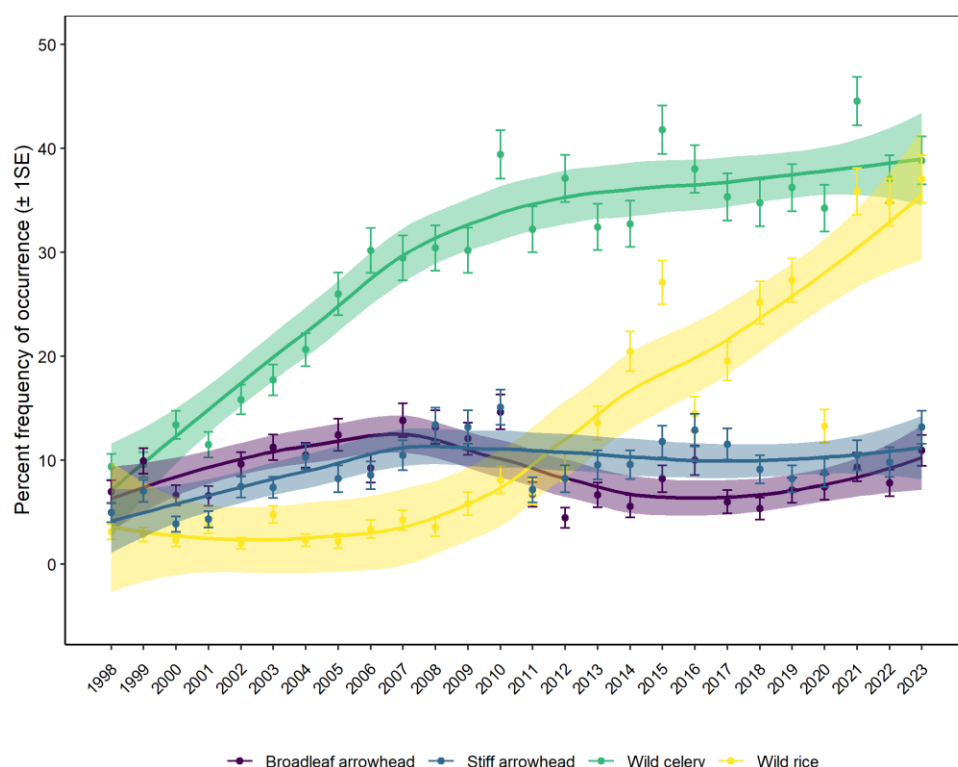


Figure 3.3. Trends in the pool-wide detection (± 1 SE) of wild celery, wild rice, and arrowheads in Pool 8 over the period of LTRM vegetation SRS monitoring. Locally weighted regression (LOESS model) trendlines (solid lines) and 95% confidence intervals (shaded areas) depict temporal patterns over the period of 1998-2023.

The Pool 8 aquatic vegetation community is composed primarily of native species, with currently only two, locally abundant invasive SAV species: Eurasian watermilfoil (*Myriophyllum spicatum* L.) and curly pondweed (*Potamogeton crispus* L.; Figure 3.4). 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, these 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 2023, prevalence of Eurasian watermilfoil and curly-leaf pondweed decreased slightly (present at 12% and 17% of sites, respectively).

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 3.4). This pattern was also observed in Pools 4 and 13 beginning in the same year (see LTRM graphical data browser). 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*.

In 2020, the invasive emergent flowering rush (*Butomus umbellatus*) made a sudden, widespread appearance in the lower half of Pool 8. This species has continued to expand each year (present at 2% of LTRM sites in 2020 and 8% of sites in 2023) and has been observed in submersed and emersed forms as well as uprooted plants growing on floating mats. Foliar herbicide treatment of ~800 acres in Pool 8 occurred in August 2022. LTRM vegetation field crews are working closely with US Fish and Wildlife Service to assess changes in percent cover of flowering rush following treatment.

Another invasive species, brittle naiad (*Najas minor*), was first detected in Pool 8 in 2021. While brittle naiad was only detected at 3 LTRM sites in 2023, visual observations suggest that the extent was similar to what was observed in 2021-2022, with highest densities growing near shorelines and in very shallow water (~0.1-0.2m). The Pool 8 vegetation crew will continue to monitor this area in subsequent years.

Figure 3.4 Prevalence of the two common submersed invasive species, curly pondweed and Eurasian watermilfoil, and the native Northern watermilfoil in Pool 8 over LTRM monitoring

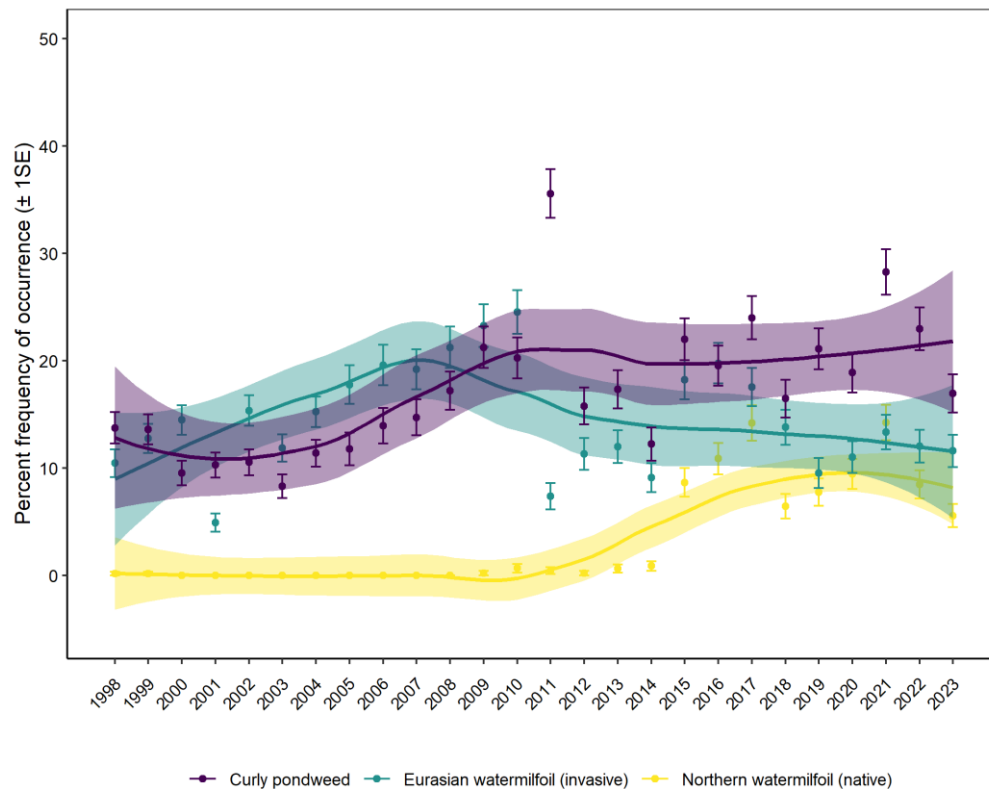


Figure 3.4. Prevalence (± 1 SE) of the two common submersed invasive species, curly pondweed and Eurasian watermilfoil, and the native Northern watermilfoil in Pool 8 over LTRM monitoring. Locally weighted regression (LOESS model) trendlines (solid lines) and 95% confidence intervals (shaded areas) depict temporal patterns over the period of 1998-2023.

Throughout LTRM monitoring, free-floating plants (algae, duckweeds, and water fern) were found to be the dominant vegetation type at ~3-20-percent of sites, with a higher probability of dominance in contiguous and isolated backwaters (Larson et al., 2022). The prevalence of free-floating plants has varied considerably over time in LTRM surveys and likely reflect short term changes in discharge, nutrients, and temperature (Figure 3.5). The profusion of algae in freshwater systems is often associated with eutrophication, a major concern for managers of the Upper Mississippi River and freshwater ecosystems in general. Filamentous algae can comprise a major component of aquatic vegetation biomass and is often found in dense mats or clinging to other aquatic vegetation species. Non-rooted floating species (duckweeds and water fern) provide food for waterfowl and valuable habitat for macro-invertebrates; however, at high densities, these species can reduce sunlight penetration and cause oxygen depletion. Detection rates of free-floating plants increased in 2023 (present at 36% of sites); however, the number of high-density filamentous algae sites (sum of all rakes > 6) decreased from 2022 to 2023 (24% and 14% of sites, respectively). The relatively high prevalence of free-floating plants in 2023 tracks well with the results of a previous metaphyton study showing that low growing season discharge combined with relatively dense submersed vegetation can allow these lifeforms to flourish (Giblin et al. 2014).

Figure 3.5 Prevalence of filamentous algae and all duckweed species combined in Pool 8 over the period of LTRM monitoring

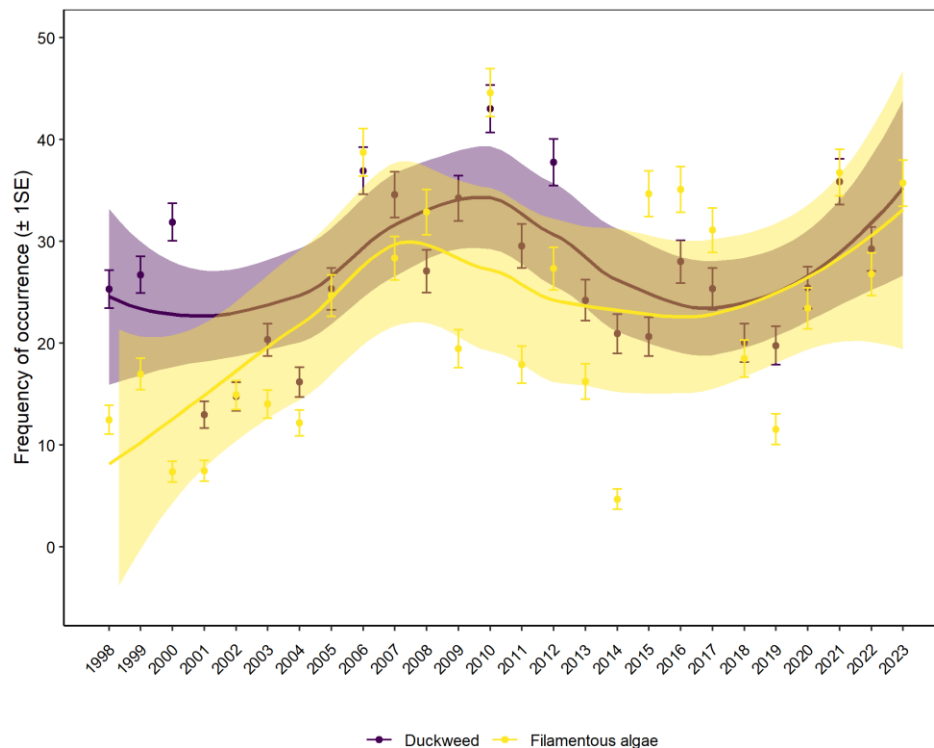


Figure 3.5. Prevalence (± 1 SE) of filamentous algae and all duckweed species combined in Pool 8 over the period of LTRM monitoring. Locally weighted regression (LOESS model) trendlines (solid lines) and 95% confidence intervals (shaded areas) depict temporal patterns over the period of 1998-2023.

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 interspersions 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 daytime 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 indicated 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 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. Beginning in 2022, the CPUE and stock-size graphs for the ten species of interest have been moved to Appendix B, and only the narrative summaries of their status will be included in the report body.

Data omissions and limitations (1993 – 2023)

In 2003, no fisheries data were collected due to budget restrictions. In 2005-2009, time period 1 sampling was not conducted, also for budgetary reasons. Daytime electrofishing and tailwater otter trawling were omitted in 2020 because of crew size limitations due to the Covid-19 pandemic. These omissions are denoted throughout the effort-dependent fisheries graphics. Catches from wingdam and fixed tailwater sites are reported in the fish community 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 LTRM Fish Graphical Data Browser at the link provided above.

Results

Effort by gear type and period

A full complement of LTRM Pool 8 fish sampling was again completed in 2023, the third year in a row where worldwide pandemics or large floods did not compromise sampling. Thus, the total number of collections was 270. Low to moderate river discharges facilitated sampling effort, though drought conditions in late summer complicated access to some areas.

Figure 4.1 Catch per sample and annual species richness

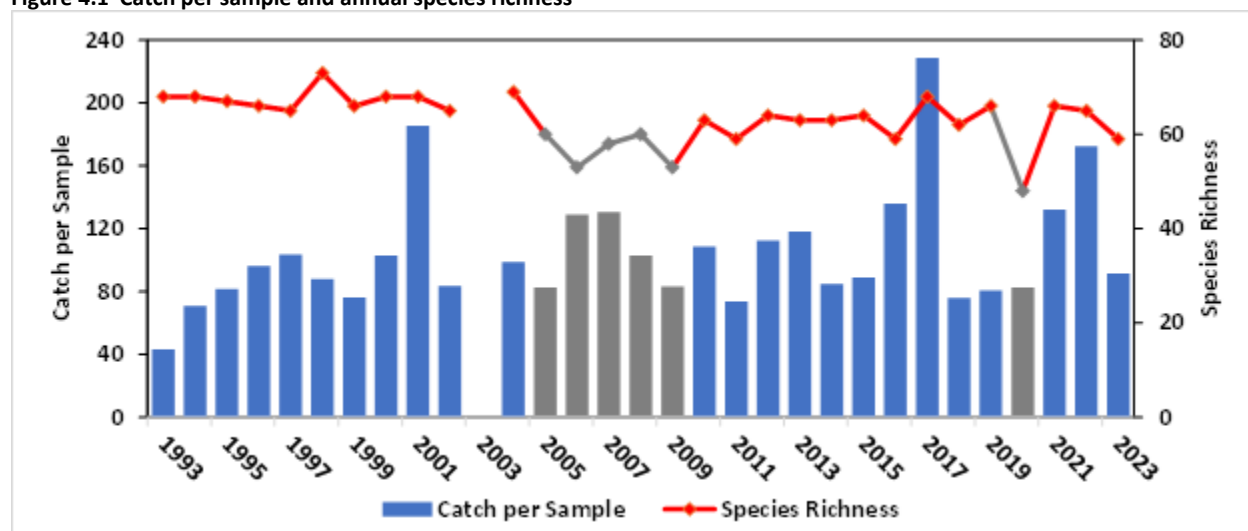


Figure 4.1. Catch per sample and annual species richness for Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element fish collections in Pool 8 of the Upper Mississippi River. Data represent samples collected with daytime electrofishing, fyke nets, mini fyke nets, large and 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.

The LTRM fish sampling allocation among gear types has remained stable since 2010, when the first sampling time period was reinstated after a decade of fiscal instability for the program. In 2023, sampling effort was highest for daytime electrofishing (84 collections), mini fyke nets (66 collections) and fyke nets (48 collections). Large and small hoop netting and tailwater trawling totaled an additional 72 collections. Effort in 2023 was greatest in the contiguous backwater stratum (84 collections), with side channel (60 collections) and main channel border (48 collections) also receiving considerable effort. The impounded shoreline (36 collections) and main channel border–wingdam (12) strata received the least effort. 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 2023 was 24,702 fish, and the catch per sample value was about average for the LTRM period of record in Pool 8 (Figure 4.1). Dense littoral aquatic vegetation and high water clarity likely decreased fishing efficiency compared to previous years. Daytime electrofishing (11,859) had the highest catches, accounting for almost 50% of the numerical total. Mini fyke nets (7,924) yielded 32%, and fyke netting (3,664) provided another 14.8%. Species richness in 2023 was 59, tied with 2011 and 2016 for the lowest value in a season wherein sampling was fully completed.

Bluegill (5,860), Largemouth Bass (3,554), Weed Shiner (3,435), Gizzard Shad (1,689), and Yellow Perch (1,231) were the top 5 species, in order of catch, in 2023 (Figure 4.2a). These top five species comprised 64% of the catch. Spottail Shiner (1,181) and Spottail Shiner (1,065) were the only other species that surpassed a thousand individuals for the year.

By weight (Figure 4.2b), Common Carp (361 kg) regained its top-ranked status, followed by Bowfin (329 kg), Shorthead Redhorse (273 kg), Bluegill (214 kg), and Silver Redhorse (212 kg). The top five species accounted for just over half of the total weight. Four other species yielded over 100 kg in 2023, including Largemouth Bass (183 kg), Channel Catfish (171 kg), Northern Pike (128 kg), and Freshwater Drum (114 kg).

Figure 4.2 Top species by a) catch and b) weight in 2023

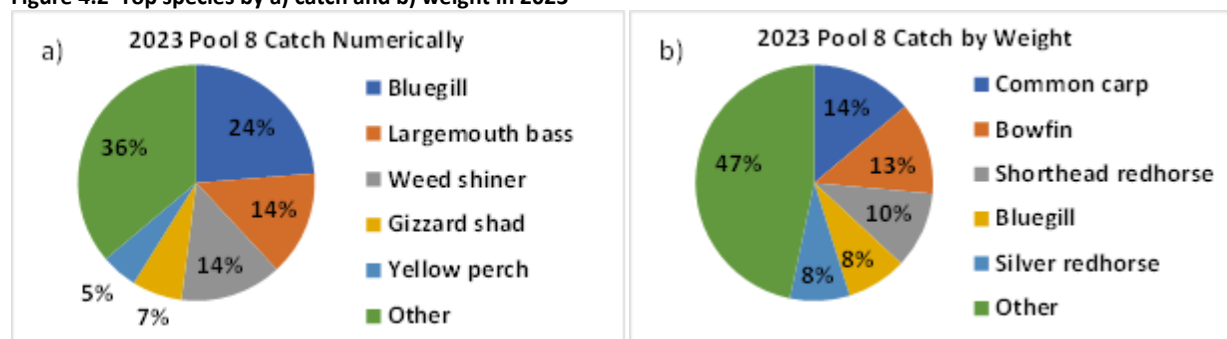


Figure 4.2. Top species by a) catch and b) weight in samples from Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element (LTRM) fish collections in Pool 8 of the Upper Mississippi River during 2023. Data represent samples collected with all current LTRM gear types.

Fish community structure

Shannon-Wiener Diversity Index (SWDI) was calculated for 2023 (Figure 4.3), based upon standardized daytime electrofishing data. The 2023 SWDI value of 2.67 continued a recent downturn, suggesting that the fish Pool 8 community has become dominated by a small number of species recently. We continue to record large numbers of lentic species such as Bluegill, Largemouth Bass, Weed Shiner, and Yellow Perch each year, whereas lotic species seem to be boom or bust. A future exercise might involve exploring community composition compared with in-season water levels, as it seems that years with higher flows have better diversity. The coincidence of low scores in the early 2000s and skipping the first sampling time period may also partly explain lower SWDI scores during that period.

Figure 4.3 Shannon Wiener Diversity Index Scores

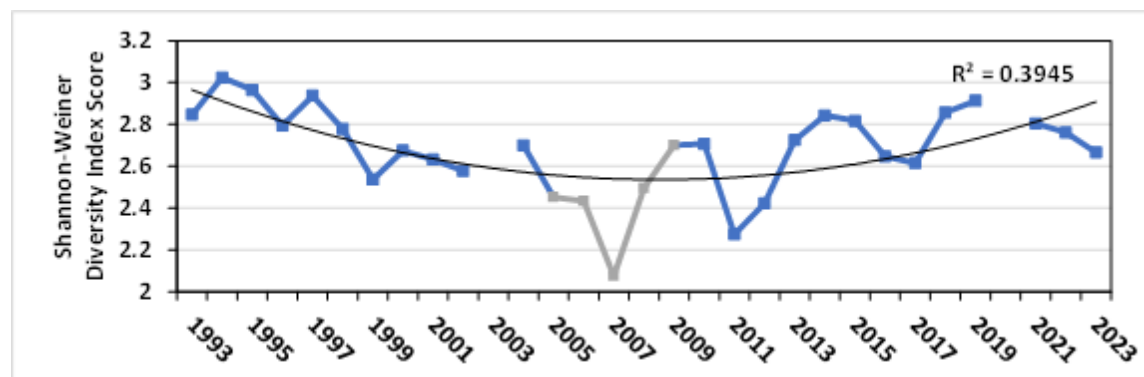


Figure 4.3. Shannon-Wiener Diversity Index Scores calculated from LTRM daytime electrofishing samples from 1993-2023 in Navigation Pool 8 of the Upper Mississippi River. Data are omitted for 2003 and 2020 due to limited

sampling those years. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. Trend line is a second-order polynomial representation of the data.

Species representation in 2023

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

Historically, 36 species have been detected in Pool 8 LTRM samples every year since SRS began in 1993, and all of these were accounted for in 2023. An additional five species have been detected in all but a single year, and these were all collected in 2023 as well. Thus, 41 fish species have essentially been present nearly every year in our sampling.

Twenty-three species have been caught in more than half of all years sampled, but have been missing in at least two years. In that group, Fathead Minnow, White Crappie, River Darter, Bigmouth Buffalo, Silver Lamprey, Orangespotted Sunfish, Sand Shiner, Silver Chub, and Highfin Carpsucker were absent during 2023. Orangespotted Sunfish and Sand Shiner are still in the group of “caught most years” fishes, but each has only been recorded twice in the last decade.

Twenty-seven species have been detected in fewer than half of sampling years. Of those, Pirate Perch, Northern Hog Sucker, Lake Sturgeon, and Pallid Shiner were caught in 2023. The Pallid Shiner occurrence was the first time since 2014, and only the third time we have recorded that species. It was verified and vouchered. Of the “less common” species, Brook Stickleback and American Brook Lamprey have only been noted twice each in the last decade; whereas, Pirate Perch and Lake Sturgeon have been recorded in 7 of the last 10 years. None of the 12 rarest species (captured in only one or two years) were sampled, nor were any new species collected in 2023. Thus, the LTRM fish species total in Pool 8 remains 91.

As reported above, we caught a Pallid Shiner in 2023, which is a Wisconsin-listed endangered species. Additionally, we caught 27 River Redhorse and one Blue Sucker, which are on the Wisconsin threatened list. We also caught 71 Mud Darters, and 1 Lake Sturgeon, each listed as species of special concern.

Through 2023, the Pool 8 LTRM sampling efforts have not detected any of the big-headed carps (Bighead, Silver, or Black), although commercial fishers and other agencies have occasionally caught them. No reproduction has been documented for these invasive species yet in Pool 8.

In 2023, we caught 181 Common Carp, currently the only non-native fish species caught by LTRM in Pool 8. The CPUE for Common Carp caught by daytime electrofishing (Figure 4.4) depicts a mostly stable catch rate for more than two decades now, after a period of much higher abundance in the early 1990s. Although Carp regained the mass-dominant position in our catches again in 2023 (4.2b), the graph of mass-per-unit-effort (MPUE) for Common Carp (Figure 4.4) illustrates a continuing trend of mass that is lower than in previous times, rather than an increase. The catch of other species in 2023 was simply low enough that they did not yield enough mass to overtake Carp.

Figure 4.4 Common Carp Catch Rates with Daytime electrofishing

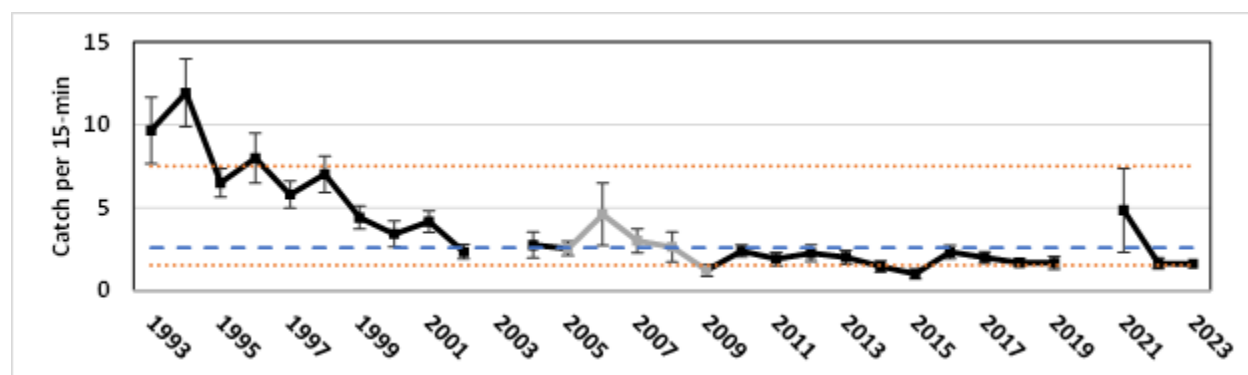


Figure 4.4. Catch per unit effort ($\pm 1SE$) of Common Carp by daytime electrofishing samples from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element fish collections in Navigation Pool 8 of the Upper Mississippi River. Data are omitted for 2003 and 2020 due to limited sampling those years. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. The dotted lines on the CPUE graph represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

It is also becoming evident that the 2021 increase in electrofishing CPUE was only a temporary aberration, and it seems unlikely that a Common Carp population rebound is imminent. That increase registered on the CPUE graph, but is not apparent on the MPUE graph. Thus, that year class either failed to recruit well, or the survivors are too small to make a difference in mass yet.

Figure 4.5 Common Carp Mass Per Unit Effort with Daytime electrofishing

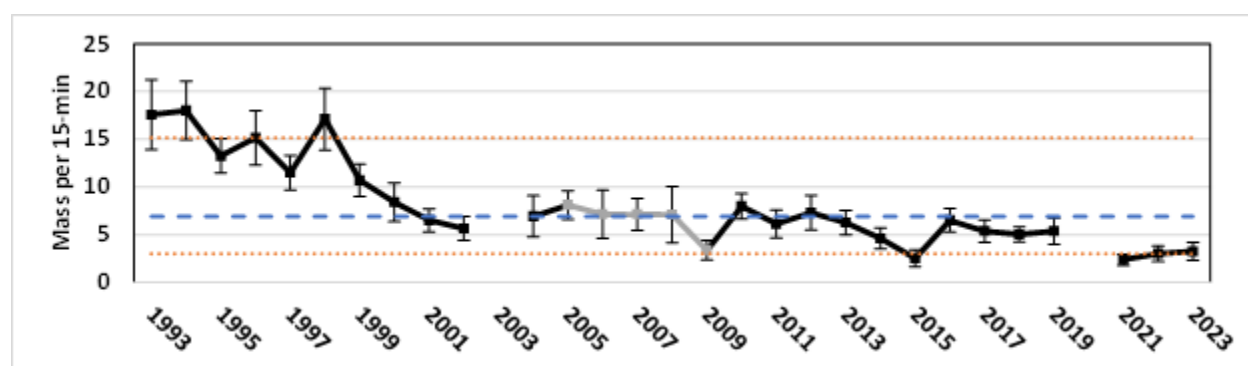


Figure 4.5. Mass (kg) per unit effort ($\pm 1SE$) of Common Carp by daytime electrofishing samples from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element fish collections in Navigation Pool 8 of the Upper Mississippi River. Data are omitted for 2003 and 2020 due to limited sampling those years. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. The dotted lines on the CPUE graph represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

Fish Community Summary

Fish catch rates, species richness, and SWDI were low in 2023, compared to recent years. The 2023 water year contained a sharp contrast between extreme high water levels in the spring and very low water during most of the sampling season, which may have influenced the fish community. Many of the usual suspects (Bluegill, Largemouth Bass, and Weed Shiner) dominated the catch, while Common Carp, Bowfin, and Shorthead Redhorse remained the top contributors by weight. The number of species that can be roughly classified as abundant, common, uncommon, and rare remained stable, and the usual state-listed species were encountered with similar frequency as in previous years, except for Lake Sturgeon, which seem to be increasing. Pool 8 is very healthy in regard to invasive fishes, as Common Carp remain the only established invader, and they have declined consistently to numbers far lower than in previous times.

Species of Interest Data

Black Crappie

Total catches of Black Crappie from all standard LTRM gear types combined have ranged from 222 in 2023 to 1,693 in 1994. The 2023 record low catch is cause for concern. The past five years have all had total catches for Black Crappie less than 500 fish, which is also the longest period of low catches we have experienced. Of the 2023 Black Crappie catch, fyke netting provided 164 fish, daytime electrofishing 27, and large hoop netting 20.

Fyke netting CPUE was below the 10th percentile setting the all-time low mark (Figure 4.6) and has only been above the average line twice in the last 12 years. Daytime electrofishing CPUE (Figure 4.7) has shown similar declines in recent years, with six consecutive years below the long-term average, and this year below the 10th percentile. Catch rates for electrofishing were about an order of magnitude lower than for fyke netting. It is unclear whether any management action could positively influence Black Crappie populations, as the mechanism for their decline is currently unknown.

Catch of substock-size (<130 mm total length (TL)) Black Crappie (Figure 4.8) in 2023 was again the lowest it has been in LTRM sampling in Pool 8 and has clearly established a downward trend. The substock-catch has been far below average in seven of the past eight years, and doubled the longest previous span of years with below average substock-catches. The chronic paucity of substock-sized fish in the catch suggests that some enduring factor has disrupted spawning or hatching success.

The Black Crappie stock-size and larger total catch graph (Figure 4.9) suggests an overall decline that began in the late 1990's and has persisted since. The greatest reductions occurred in stock- and quality-size classes, whereas the number of preferred- and memorable-sizes of Black Crappies caught has remained consistent. Thus, the Black Crappie population in Pool 8 seems to be a shrinking and aging population at present, though all size classes of fish are at least still present. Strong substock-size classes in 2014 and 2015, and stronger quality-size classes in 2013 and 2017 suggest habitat conditions can still be favorable for Black Crappie populations to rebound. It is unclear whether any management action could positively influence Black Crappie populations, as the mechanism for their decline is currently unknown.

Bluegill

Total catches of Bluegill from all standard LTRM gear types combined have ranged from 1,685 in 1994 to 12,026 in 2010. We caught 5,860 Bluegill in 2023, an average catch. Of those, 2,173 were caught by fyke netting, 2,162 by daytime electrofishing, and 1,295 by mini fyke netting.

Bluegill fyke net CPUE (Figure 4.10) and daytime electrofishing (Figure 4.11) during the first decade of LTRM fish sampling were low, increased steadily through the latter 1990's and early 2000's, and then experienced a downturn in the 2010's. In 2023, CPUE for fyke netting and daytime electrofishing both decreased modestly and were at or near the long-term mean for both sampling gears. Recent years have had slightly better catch rates than the late 2010's.

Catches of substock-sized (<80 mm TL) Bluegill (Figure 4.12) in 2023 were low for the 7th time in the last 10 years. It is essential for Bluegills to have a successful year class once every four to five years, as very few of them survive longer than five years. Figure 4.12 demonstrates that Bluegills are at least pulling off a good hatch of young fish every fourth year or so, and are still in decent shape.

We did not catch a memorable-size (>250 mm TL) Bluegill in 2023, and had only 39 preferred-size (200-249 mm TL) Bluegills (Figure 4.13). Angling mortality may be a factor in the noticeable reduction in number of Bluegills between quality- (150-199 mm TL) and preferred- size. The number of quality-sized Bluegill seems stable, relative to the high variability in the number of stock-sized (80-149 mm TL) fish. The catch of stock- and quality-sized Bluegill in 2023 was high again, perhaps portending a bright future. The number of substock-sized Bluegill does not always seem to translate into stock-sized fish the next year or following year. 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.

Channel Catfish

Total catches of Channel Catfish from all standard LTRM gear types combined have ranged from 88 in 2009 to 1,004 in 2002. We caught 162 Channel Catfish in 2023. Large-hoop nets provided 136 Channel Catfish, and small-hoop nets yielded only 12 catfish. Channel Catfish CPUE in large-hoop nets decreased in 2023 (Figure 4.14) to about halfway between the mean and the 90th percentile among the LTRM SRS years, suggesting that adult catfish populations are thriving. Small-hoop netting CPUE (Figure 4.15), which best represents younger year classes, decreased to near zero in 2023. The overall CPUE trends suggest an aging population, with large-hoop nets

sampling a robust adult Channel Catfish population, but small-hoop nets failing to detect any strong replacement year classes recruiting into the gear.

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 4.16). Many of these were caught by trawling, although the CPUE for small-hoop nets depicts a similar pattern as the substock-size graph. Substock-sized Channel Catfish in 2023 was very low, totaling only 9 fish.

Stock- (280-409 mm TL) and quality-sized (410-609 mm TL) Channel Catfish dominated the LTRM Pool 8 catch through 2000 (Figure 4.17), but preferred- (610-709 mm TL) and memorable-sized (>710 mm TL) fish have become relatively more common since then. Despite poor catches in 2023, all stock sizes were collected, but in lower numbers than usual.

Flathead Catfish

Total catches of Flathead Catfish from all standard LTRM gear types combined have ranged from 9 in 2006 to 101 in 1998. We caught 33 Flathead Catfish in 2023, 12 of which came from large hoop-netting and 10 from fyke netting. CPUE from large-hoop nets (Figure 4.18) decreased in 2023 from a near-record high to the long-term mean; whereas, daytime electrofishing CPUE (Figure 4.19) decreased to only slightly above the 10th percentile. It is very possible that Flatheads were simply using habitats that we don't sample well, as water levels were low throughout the sampling season.

Catches of substock-sized (<350 mm TL) Flathead Catfish (Figure 4.20) were higher in the 1990's, then dipped, rebounded, and dipped again. We caught only two substock-sized Flathead Catfish in 2023, but that is not a cause of concern for these long-lived fish, as most adults seemingly have a number of spawning opportunities during their lifetimes.

The graph of adult-sized Flathead Catfish (Figure 4.21) shows a healthy mix of all stock-sizes, and is consistent with the gear-specific catch, where multiple gear types yielded Flatheads. Despite recent lower catches, the population is likely healthy, with annual fluctuations likely indicative of variability in sampling locations and efficiency rather than changes in abundance.

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 3,554 Largemouth Bass in 2023, about 2/3 of them (2,121) by daytime electrofishing, and the other third by mini fyke netting (1,263). Daytime electrofishing CPUE (Figure 4.22) was nearly tied with the all-time high from 2007, suggesting the population is increasing.

The catch graph of substock-sized (<200 mm TL) Largemouth Bass (Figure 4.23) helps explain the increase in electrofishing CPUE, showing that both 2022 and 2023 were exceptional years for young Largemouths. Any time an anomaly of this magnitude occurs, it is important to observe future effects, in this case, whether those young fish recruit to the adult population.

Indeed, the catch of adult Largemouth Bass (Figure 4.24) depicts an increase in stock-sized (200-299 mm TL) fish, with quality- (300-379 mm TL) and preferred-size (400-509 mm TL) Largemouth Bass catches being stable. Aside from the memorable category being essentially non-existent, Largemouth Bass populations seem to be healthy and perhaps, increasing.

Northern Pike

Total catches of Northern Pike from all standard LTRM gear types combined have ranged from 51 in 2000 to 203 in 2022. In 2023, we nearly equaled that benchmark and caught 202 Northern Pike. Day electrofishing (126) produced two thirds of the catch, and fyke netting added 58 pike. Fyke netting CPUE (Figure 4.25) decreased again in 2023, but remained above the long-term mean. Daytime electrofishing CPUE (Figure 4.26) reached stratospheric heights to more than double the long-term average. The somewhat contrasting trends for these two gears, suggests there is more to the story, that perhaps the stock size analyses will inform.

The catch of substock-sized (<350 mm TL) Northern Pike (Figure 4.27) was only a single fish (89) below the record set in 2022. Certainly, there are multiple factors that determine year-class strength, but a cursory examination of

the spring flood data (Table 1) compared to the substock-sized Northern Pike graph (Figure 4.27) suggests that spring flood duration and magnitude likely influence spawning success. In four of six years with low substock Northern Pike catches (2000, 2007, 2012, and 2021), the spring flood duration was much shorter than usual; conversely, in six of eight years where the substock catch was above normal, the spring flood duration was robust (2001, 2013, 2014, 2019, 2022, and 2023).

Catches of stock-sized (350-529 mm TL) Northern Pike (Figure 4.28) 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. Thus, it seems that recruitment and adult mortality are likely stable, and the driving factor for Northern Pike populations is spawning success. The highest catch of stock-sized Northern Pike in the entire sampling period occurred in 2021, but followed a seemingly poor substock-size class in 2020. If the poor catch of substock-size fish in 2020 was explained by the omission of daytime electrofishing from the sampling, then it might follow that a sizable year class was produced in 2020 after all, and was simply missed in the dataset because of the lack of electrofishing. Memorable-sized (>860 mm TL) Northern Pike were more prevalent in the first two decades of LTRM. The LTRM graphical fish browser shows that Proportional Stock-Density for Northern Pike in Pool 8 has decreased in recent years, which is consistent with a population of younger and smaller fish ([Long Term Resource Monitoring Element - Graphical Fish Database Browser \(usgs.gov\)](https://www.usgs.gov/monitoring-element-graphical-fish-database-browser).) This may be a compensatory mechanism related to higher survival rates as aquatic vegetation has become abundant. Feeding efficiency may also be reduced with greater vegetation density. A growth rate study might show interesting results if bony structures from the earlier LTRM period are available to compare with current data.

Sauger

Total catches of Sauger from all standard LTRM gear types combined have ranged from 4 in 2020 (when electrofishing was not accomplished) to 314 in 1998. We caught 22 Sauger in 2023. Daytime electrofishing produced 20 of the Saugers caught. The daytime electrofishing CPUE graph (Figure 4.29) ticked back upward to the long-term mean value in 2023.

We caught 14 substock-sized (<200 mm TL) Sauger (Figure 4.30), which is tied for the most since 2007. Certainly, there is a long way to go before the data suggest a recovery, but signs of hope are a welcome change to this long, bleak picture of low abundances.

Conversely, the graph of stock-size and larger Sauger (Figure 4.31) shows such a small number of adult Saugers in the catch, that it is difficult to discern much of anything. Between two and four Saugers were still recorded for each of the adult stock categories.

Smallmouth Bass

Total catches of Smallmouth Bass from all standard LTRM gear types combined have ranged from 29 in the COVID-19-affected 2020 sampling season to 550 in 1998. We caught 148 Smallmouth Bass in 2023, 135 of those with daytime electrofishing. The CPUE graph of daytime electrofishing (Figure 4.32) showed a decrease to the 10th percentile. Any hopes that the 2018- and 2019- year classes might rebuild the population are essentially gone.

The graph of substock-sized (<180 mm TL) Smallmouth Bass (Figure 4.33) reveals a below-average number of small fish in 2023. The Smallmouth Bass population certainly seems capable of producing enough young to replenish and expand the population, given the appropriate conditions.

The graph of stock- and larger sized Smallmouth Bass (Figure 4.34) shows all four adult stock categories present, albeit in low numbers compared to most previous years. Smallmouth Bass are certainly not as abundant as they once were, but seem to be holding their own.

Walleye

Total catches of Walleye from all standard LTRM gear types combined have ranged from 12 in 2009 to 138 in 1997. We caught 34 Walleyes in 2023. Daytime electrofishing provided 23 of the Walleyes sampled in 2023, with the others scattered amongst four gear types. Daytime electrofishing CPUE (Figure 4.35) decreased slightly in 2023, and was below the long-term average. Fyke netting CPUE (Figure 4.36) remained below the long-term average for the third consecutive year.

We caught 9 substock-sized (<250 mm TL) Walleyes in 2023 (Figure 4.37), which was below the long-term average, and the lowest over the last four years. Unfortunately, the 2018 year-class is likely reaching the last few years of its existence, and time for them to pull off a big hatch is running out.

The graph of stock-size and larger Walleyes (Figure 4.38) shows a healthy mixture of size classes present, albeit, at modest numbers. Much as with Sauger, if reproductive success could be increased, it seems that conditions for growth and survival of adult fish exist.

Yellow Perch

Total catches of Yellow Perch from all standard LTRM gear types combined have ranged from 53 in 2000 to 1,687 in 2022. We caught 1,231 Yellow Perch in 2023. Daytime electrofishing yielded 710 perch and fyke netting produced an additional 498. Fyke netting CPUE (Figure 4.39) remained at the 90th percentile for the period of record. Daytime electrofishing CPUE for Yellow Perch (Figure 4.40) decreased slightly from 2022, but was still near the 90th percentile.

We caught 167 substock-sized (<130 mm TL) Yellow Perch (Figure 4.41), which was disappointing, given that the spring flood was very large. Perhaps the maximum flows were so great that eggs and larvae were dislodged or damaged.

The graph of stock-size and larger Yellow Perch (Figure 4.42) shows a huge contingent of stock-sized (130-199 mm TL) perch, and stable numbers of larger size categories. Thus, despite the paucity of substock-sized fish in the catch in 2023, it seems that the population of Yellow Perch is in fantastic shape.

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Appendix A. Species list and years detected in LTRM Pool 8 samples. Species in green rows have been detected every year, those in blue have been detected in half or more of years, those in orange less than half of years, and those in pink only single years.

Common Name	Years Caught	Common Name	Years Caught
Black crappie	31	Slenderhead darter	27
Bluegill	31	Fathead minnow	26
Bowfin	31	Mooneye	26
Brook silverside	31	Central mudminnow	25
Bullhead minnow	31	Western sand darter	25
Channel catfish	31	White crappie	25
Common carp	31	White sucker	25
Emerald shiner	31	Black bullhead	24
Freshwater drum	31	River darter	24
Gizzard shad	31	Bigmouth buffalo	22
Golden redhorse	31	Silver lamprey	21
Golden shiner	31	Blue sucker	20
Green sunfish	31	Orangespotted sunfish	17
Johnny darter	31	Sand shiner	17
Largemouth bass	31	Silver chub	17
Logperch	31	Highfin carpsucker	17
Longnose gar	31	Trout perch	16
Mimic shiner	31	Banded darter	16
Northern pike	31	Brown bullhead	14
Pumpkinseed	31	Pirate perch	12
River redhorse	31	Northern hog sucker	12
River shiner	31	Lake sturgeon	11
Rock bass	31	Burbot	10
Sauger	31	Shoal chub	10
Shorthead redhorse	31	Bluntnose minnow	9
Silver redhorse	31	Iowa darter	9
Smallmouth bass	31	Mississippi silvery minnow	8
Smallmouth buffalo	31	Yellow bass	8
Spotfin shiner	31	Blackside darter	8
Spottail shiner	31	Stonecat	7
Spotted sucker	31	Brook stickleback	6
Tadpole madtom	31	American brook lamprey	6
Walleye	31	Pallid shiner	3
Weed shiner	31	Brassy minnow	2
White bass	31	Brown trout	2
Yellow perch	31	Crystal darter	2
Flathead catfish	30	Fantail darter	2
Mud darter	30	Black buffalo	2
Quillback	30	Rainbow smelt	1
Shortnose gar	30	American eel	1
Warmouth	30	Goldeye	1
Pugnose minnow	29	Creek chub	1
Yellow bullhead	29	Central stoneroller	1
River carpsucker	28	Skipjack herring	1
Chestnut lamprey	27	Largescale stoneroller	1
Shovelnose sturgeon	27		

Appendix B. Catch-per-unit-effort and stock abundance for Fish Species of interest in Navigation Pool 8 of the Upper Mississippi River.

Catch per unit effort ($\pm 1SE$) of Black Crappie by fyke netting

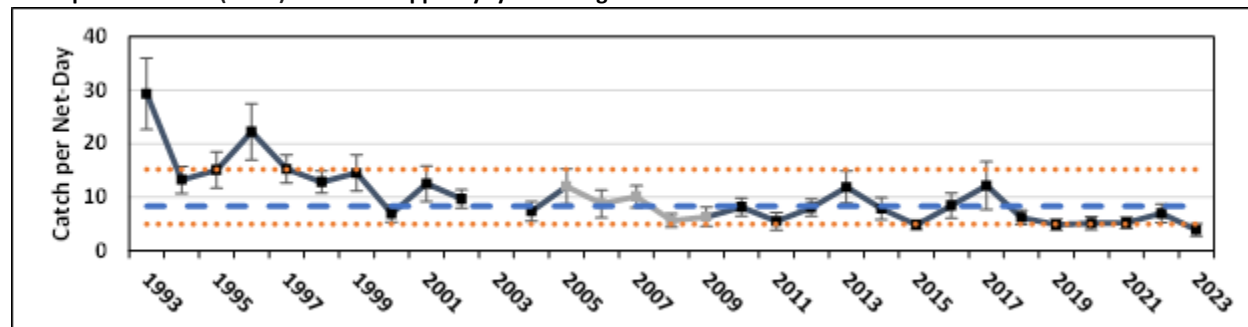


Figure 4.6. Catch per unit effort ($\pm 1SE$) of Black Crappie in fyke netting samples from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element fish collections in Navigation Pool 8 of the Upper Mississippi River. Data are omitted for 2003 due to limited sampling that year. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. The dotted lines on the CPUE graph represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

Catch per unit effort ($\pm 1SE$) of Black Crappie by daytime electrofishing

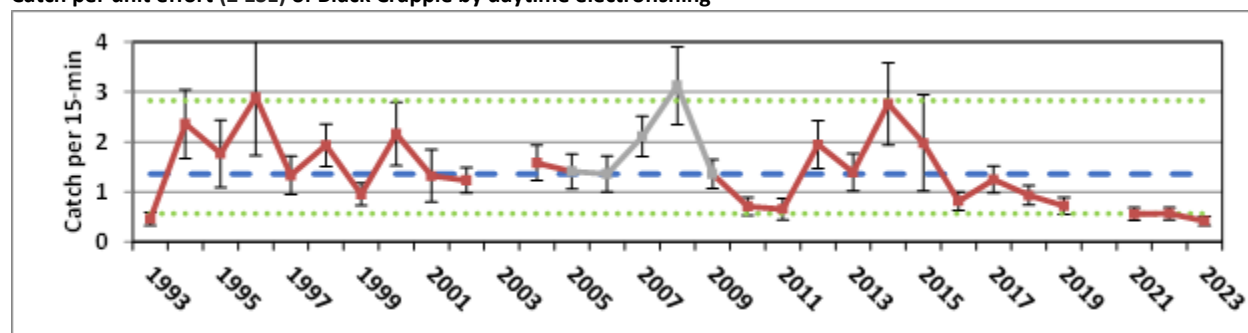


Figure 4.7. Catch per unit effort ($\pm 1SE$) of Black Crappie in daytime electrofishing samples from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element fish collections in Navigation Pool 8 of the Upper Mississippi River. Data are omitted for 2003 and 2020 due to limited sampling those years. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. The dotted lines on the CPUE graph represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

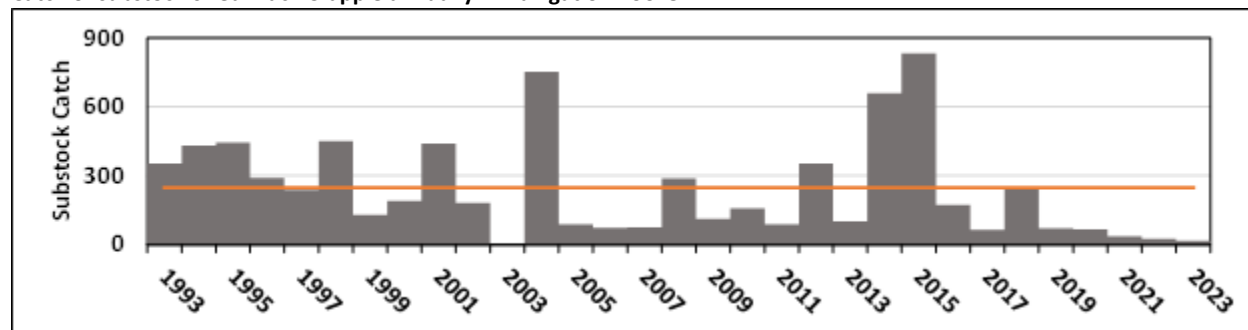
Catch of substock-sized Black Crappie annually in Navigation Pool 8

Figure 4.8. 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. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

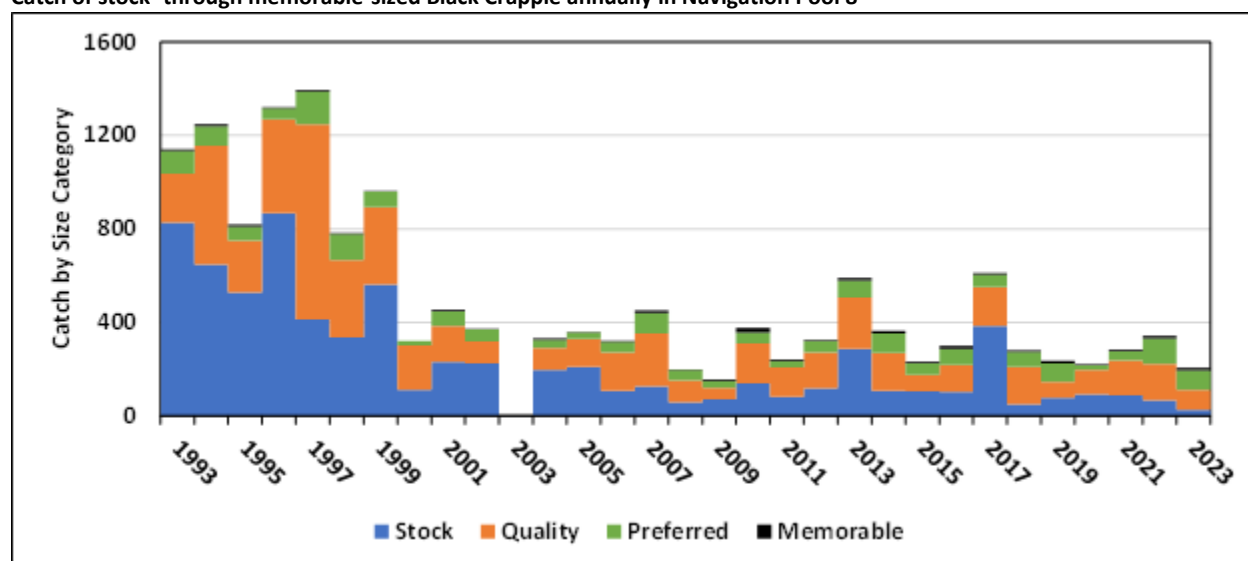
Catch of stock- through memorable-sized Black Crappie annually in Navigation Pool 8

Figure 4.9. 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. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

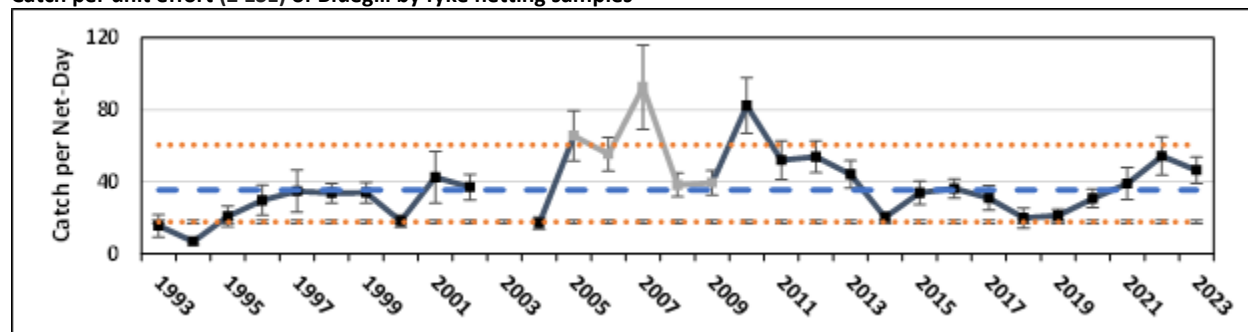
Catch per unit effort (± 1 SE) of Bluegill by fyke netting samples

Figure 4.10. Catch per unit effort (± 1 SE) 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. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. The dotted lines on the CPUE graph represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

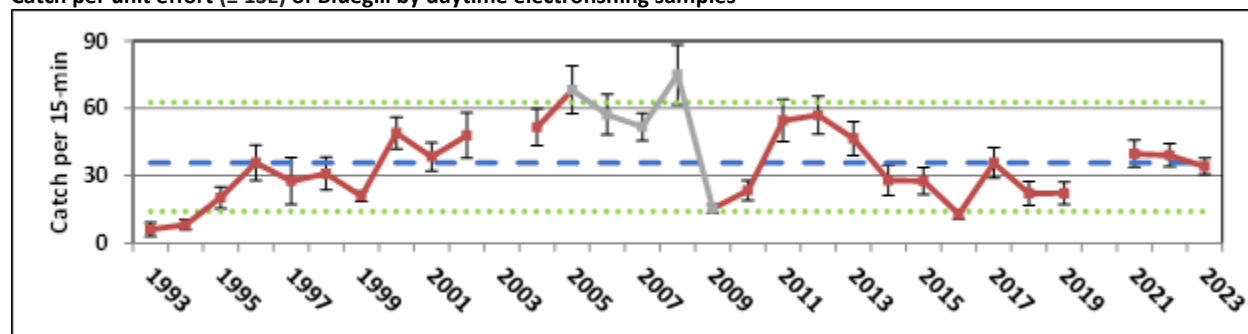
Catch per unit effort (± 1 SE) of Bluegill by daytime electrofishing samples

Figure 4.11. Catch per unit effort (± 1 SE) of Bluegill in daytime electrofishing 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 and 2020 due to limited sampling those years. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. The dotted lines on the CPUE graph represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

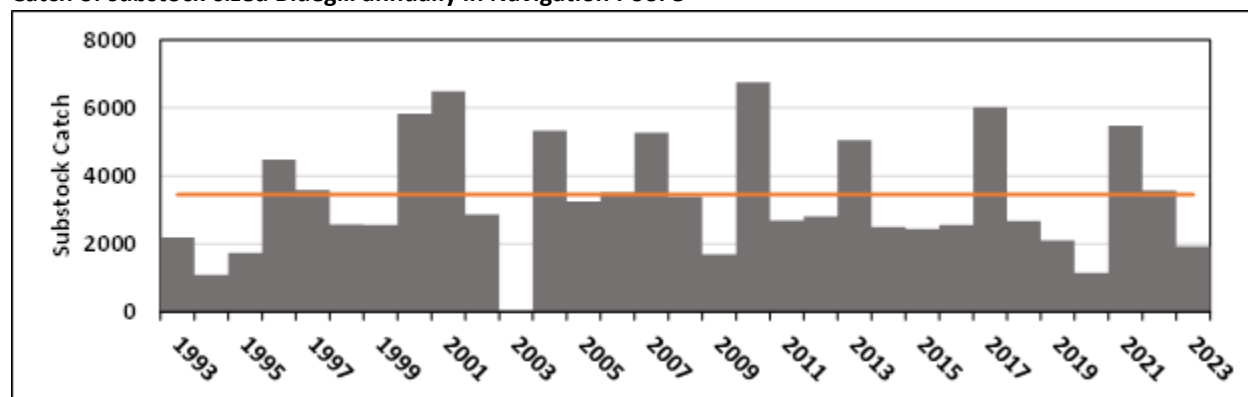
Catch of substock-sized Bluegill annually in Navigation Pool 8

Figure 4.12. 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. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

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

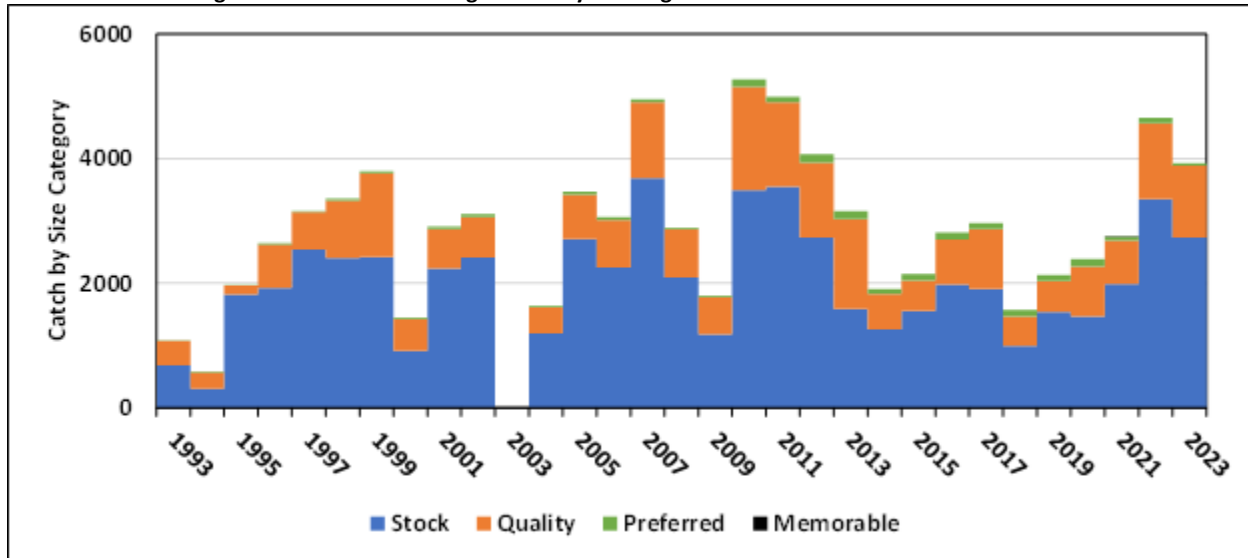


Figure 4.13. Catch of stock- through memorable-sized Bluegill annually in Navigation Pool 8 of the Upper Mississippi River by all gears combined from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element. Data are omitted for 2003 due to limited sampling that year. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

Catch per unit effort (± 1 SE) of Channel Catfish by large-hoop netting

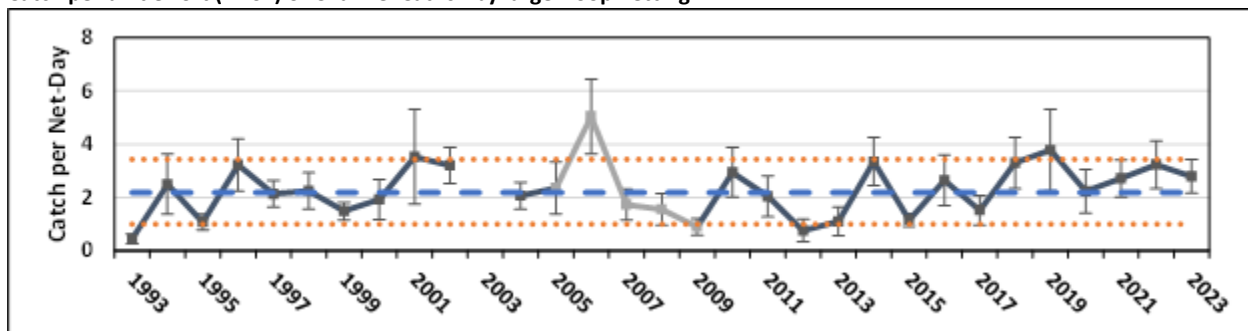


Figure 4.14. Catch per unit effort (± 1 SE) of Channel Catfish by large-hoop net samples from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element fish collections in Navigation Pool 8 of the Upper Mississippi River. Data are omitted for 2003 due to limited sampling that year. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. The dotted lines on the CPUE graph represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

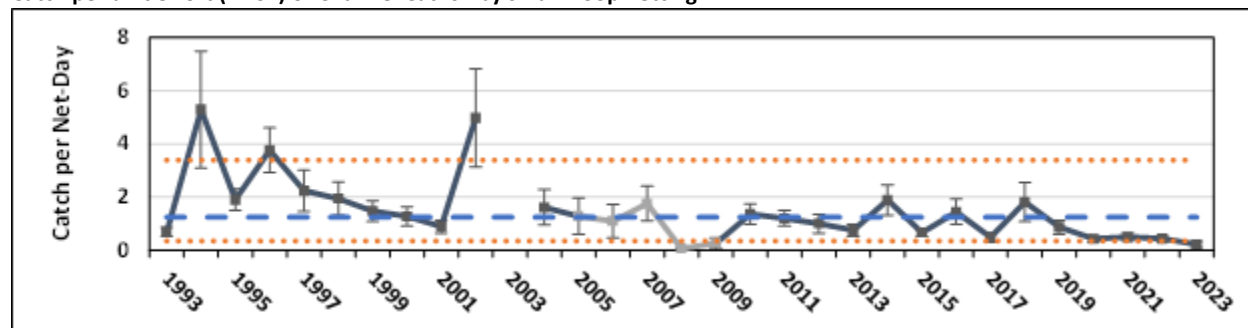
Catch per unit effort (± 1 SE) of Channel Catfish by small-hoop netting

Figure 4.15. Catch per unit effort (± 1 SE) of Channel Catfish by small-hoop net 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. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. The dotted lines on the CPUE graph represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

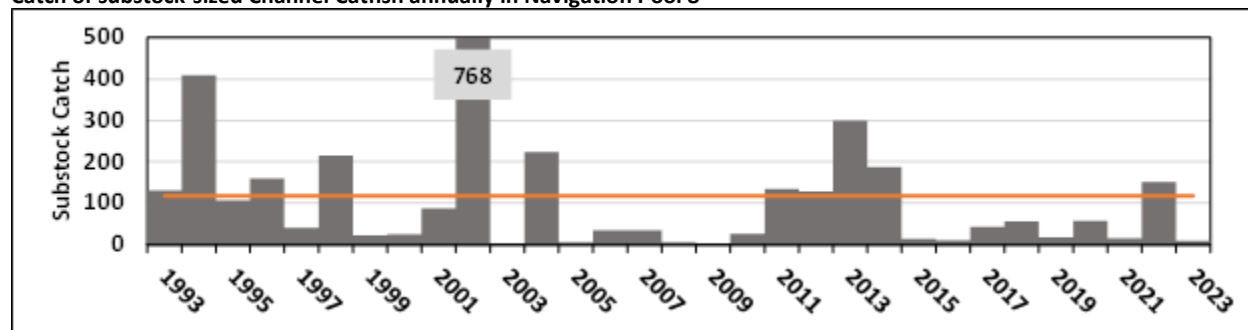
Catch of substock-sized Channel Catfish annually in Navigation Pool 8

Figure 4.16. 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. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

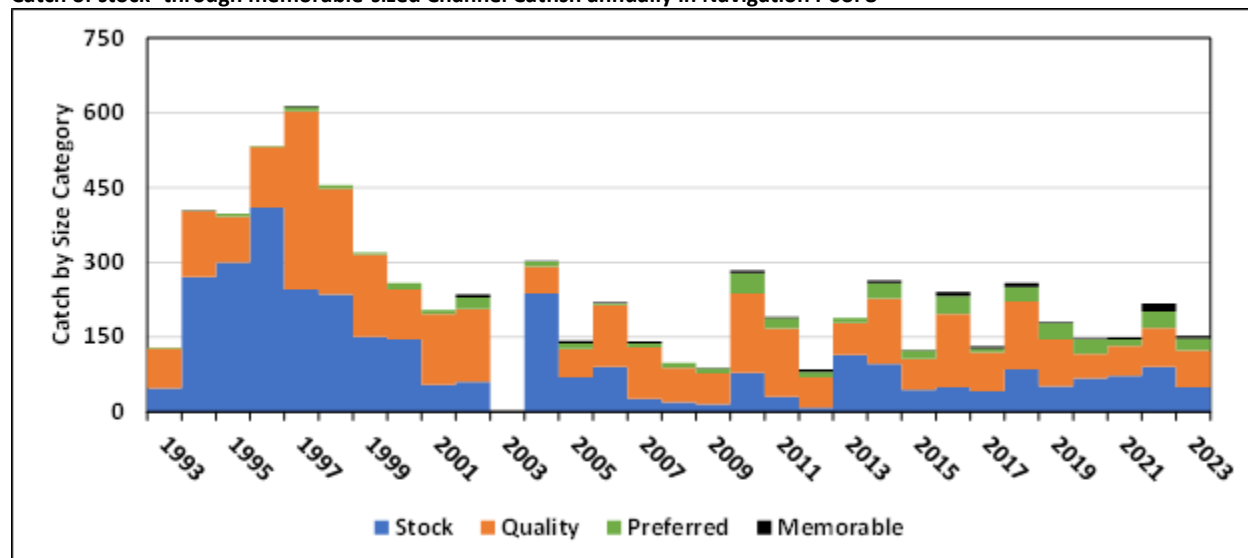
Catch of stock- through memorable-sized Channel Catfish annually in Navigation Pool 8

Figure 4.17. 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. Data are omitted for 2003 due to limited sampling that year. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

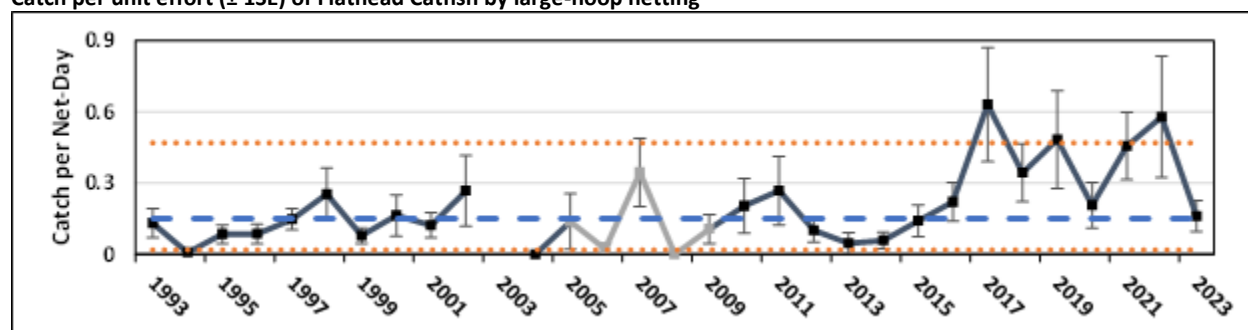
Catch per unit effort ($\pm 1SE$) of Flathead Catfish by large-hoop netting

Figure 4.18. Catch per unit effort ($\pm 1SE$) 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. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. The dotted lines on the CPUE graph represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

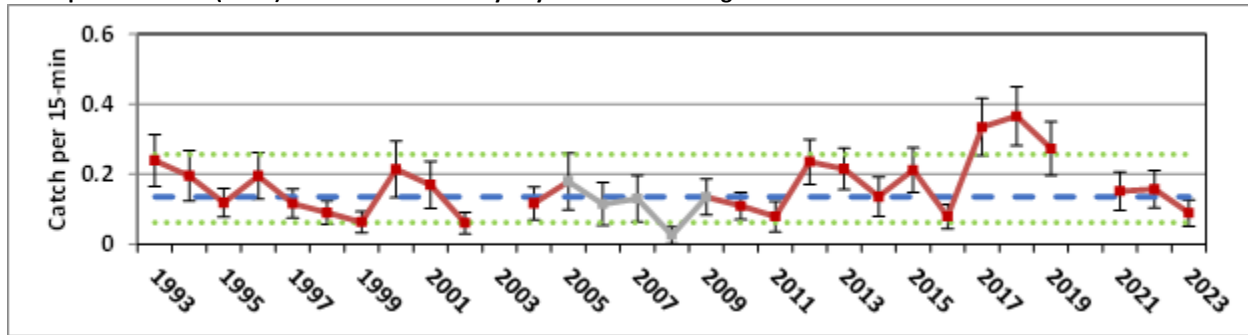
Catch per unit effort (± 1 SE) of Flathead Catfish by daytime electrofishing

Figure 4.19. Catch per unit effort (± 1 SE) of Flathead Catfish in daytime electrofishing 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 and 2020 due to limited sampling those years. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. The dotted lines on the CPUE graph represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

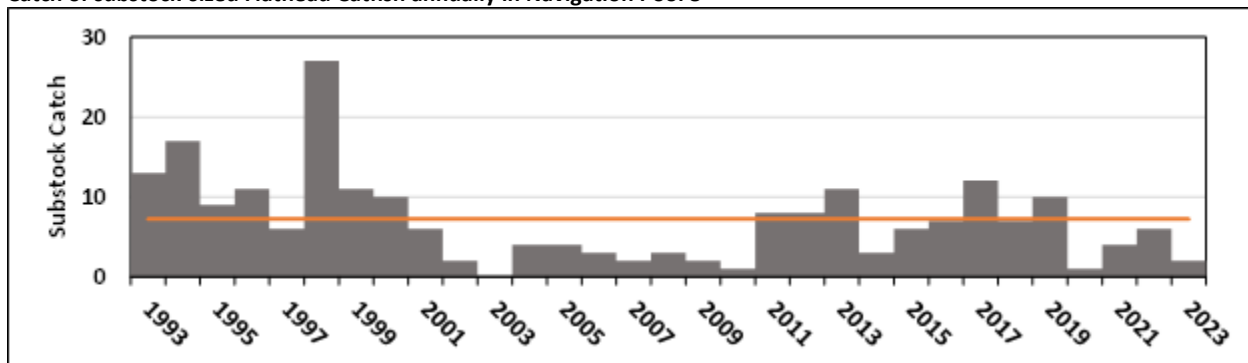
Catch of substock-sized Flathead Catfish annually in Navigation Pool 8

Figure 4.20. 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. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

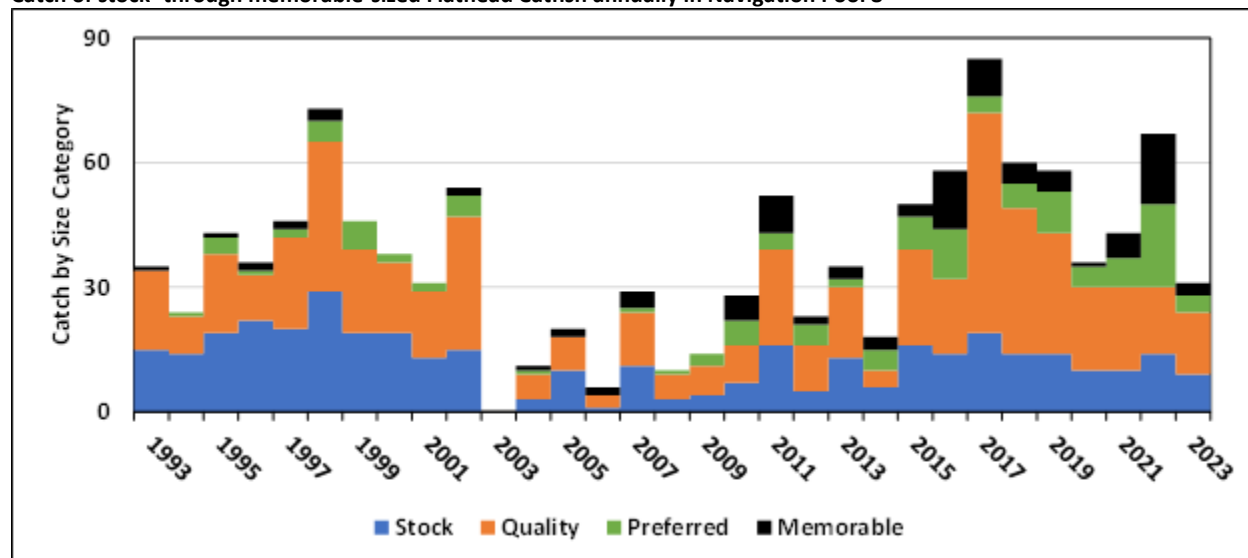
Catch of stock- through memorable-sized Flathead Catfish annually in Navigation Pool 8

Figure 4.21. 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. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

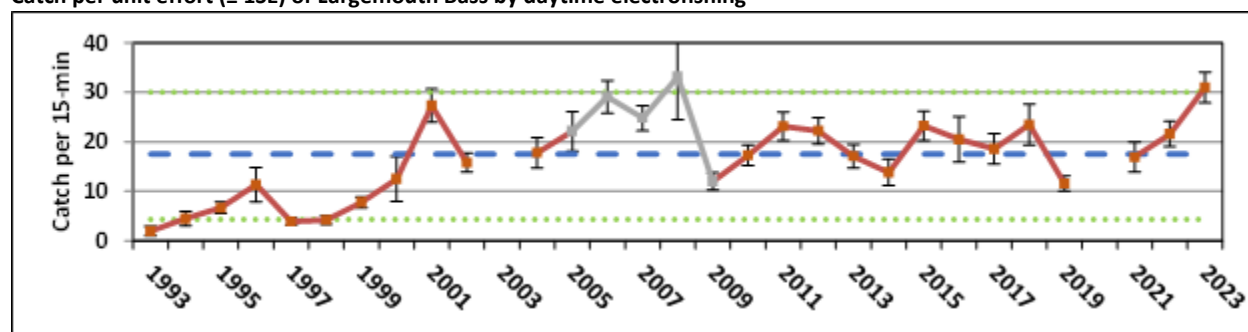
Catch per unit effort ($\pm 1SE$) of Largemouth Bass by daytime electrofishing

Figure 4.22. Catch per unit effort ($\pm 1SE$) of Largemouth Bass in daytime electrofishing 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 and 2020 due to limited sampling those years. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. The dotted lines on the CPUE graph represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

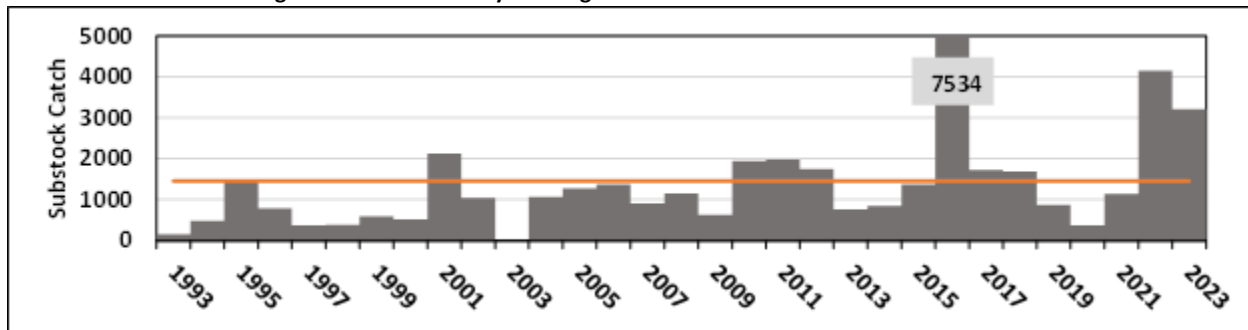
Catch of substock-sized Largemouth Bass annually in Navigation Pool 8

Figure 4.23. Catch of substock-sized Largemouth Bass 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. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting. Note - the historically-high catch of substock-sized Largemouth Bass in 2016 is not shown to scale.

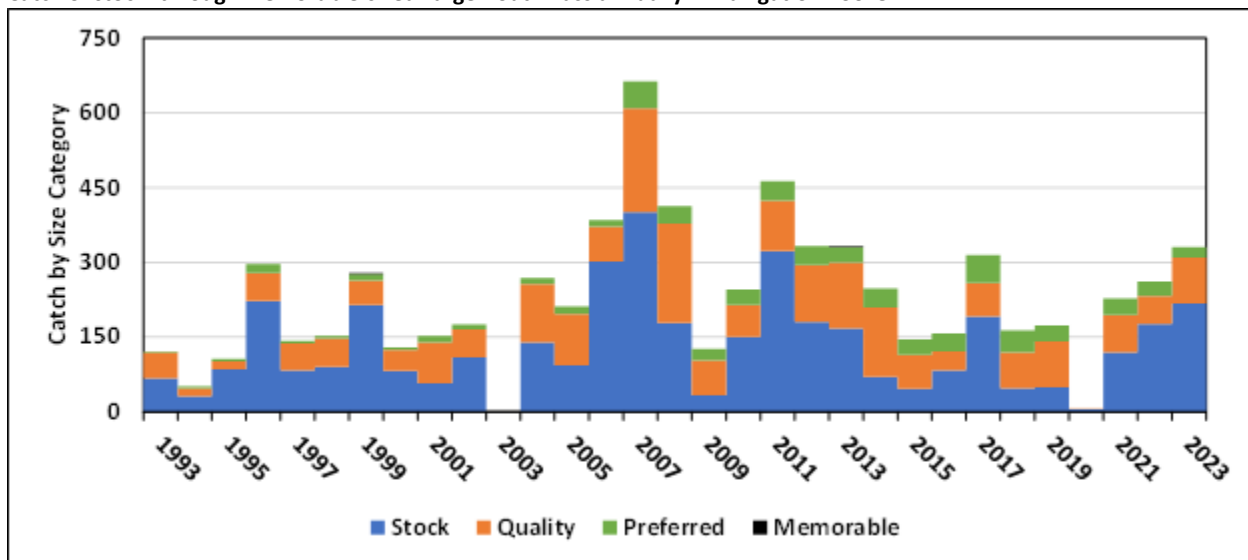
Catch of stock- through memorable-sized Largemouth Bass annually in Navigation Pool 8

Figure 4.24. Catch of stock- through memorable-sized Largemouth Bass 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. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

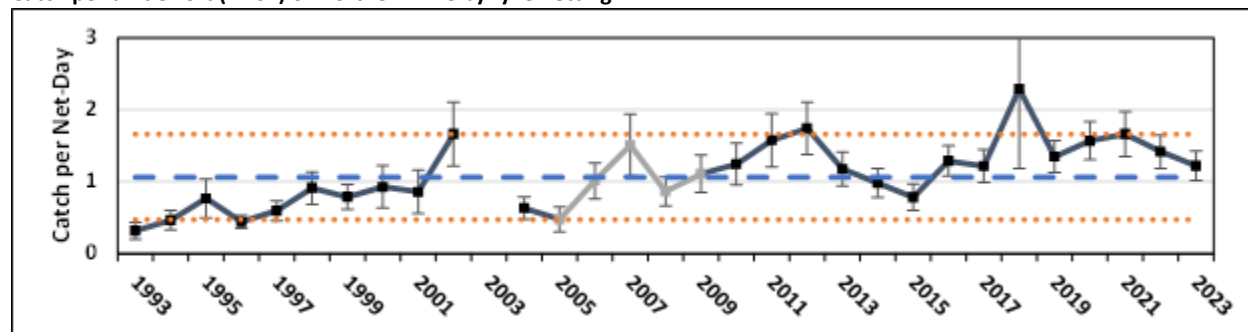
Catch per unit effort ($\pm 1SE$) of Northern Pike by fyke netting

Figure 4.25. Catch per unit effort ($\pm 1SE$) 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. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. The dotted lines on the CPUE graph represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

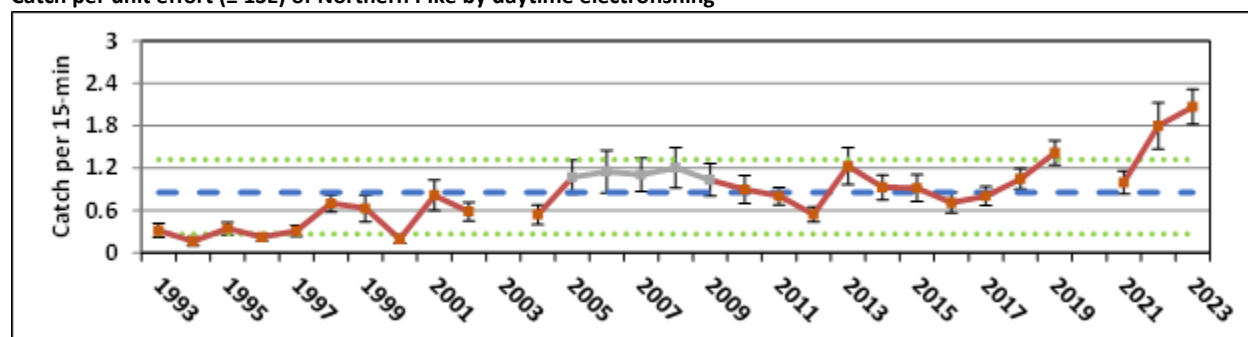
Catch per unit effort ($\pm 1SE$) of Northern Pike by daytime electrofishing

Figure 4.26. Catch per unit effort ($\pm 1SE$) of Northern Pike by daytime electrofishing 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 and 2020 due to limited sampling those years. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. The dotted lines on the CPUE graph represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

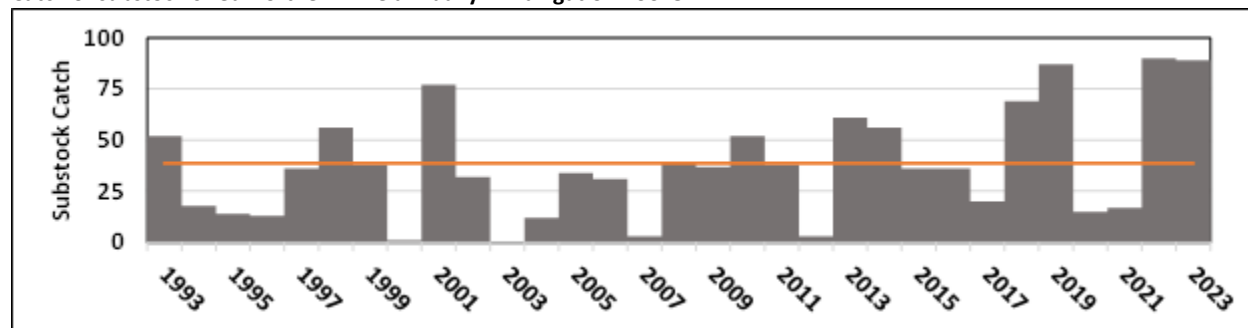
Catch of substock-sized Northern Pike annually in Navigation Pool 8

Figure 4.27. 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. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

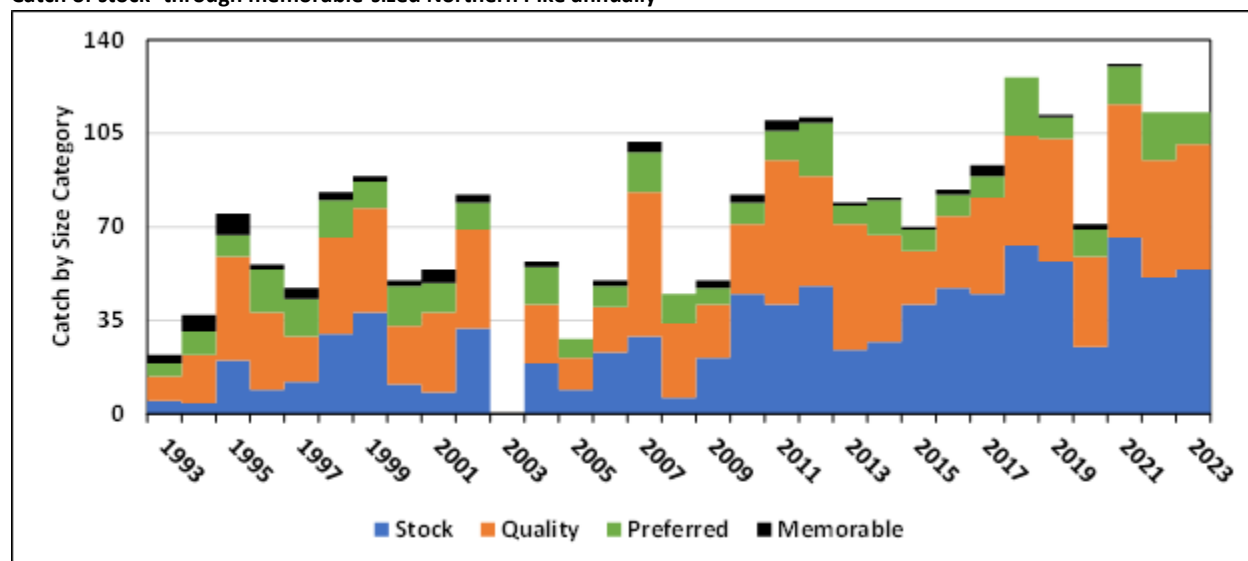
Catch of stock- through memorable-sized Northern Pike annually

Figure 4.28. 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. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

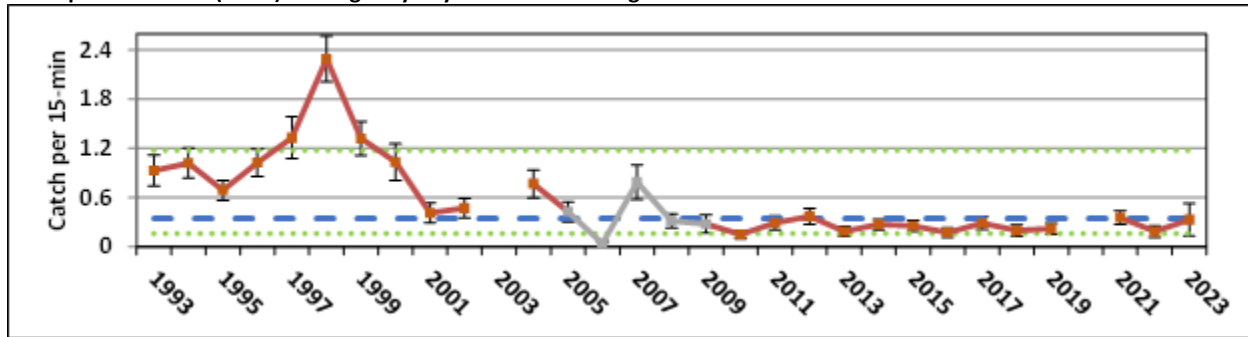
Catch per unit effort ($\pm 1SE$) of Sauger by daytime electrofishing

Figure 4.29. Catch per unit effort ($\pm 1SE$) of Sauger by daytime electrofishing 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 and 2020 due to limited sampling those years. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. The dotted lines on the CPUE graph represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

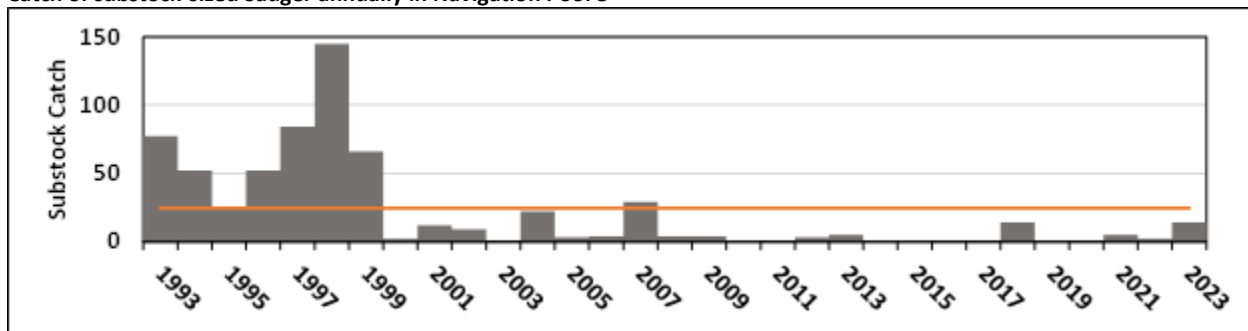
Catch of substock-sized Sauger annually in Navigation Pool 8

Figure 4.30. Catch of substock-sized Sauger 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. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

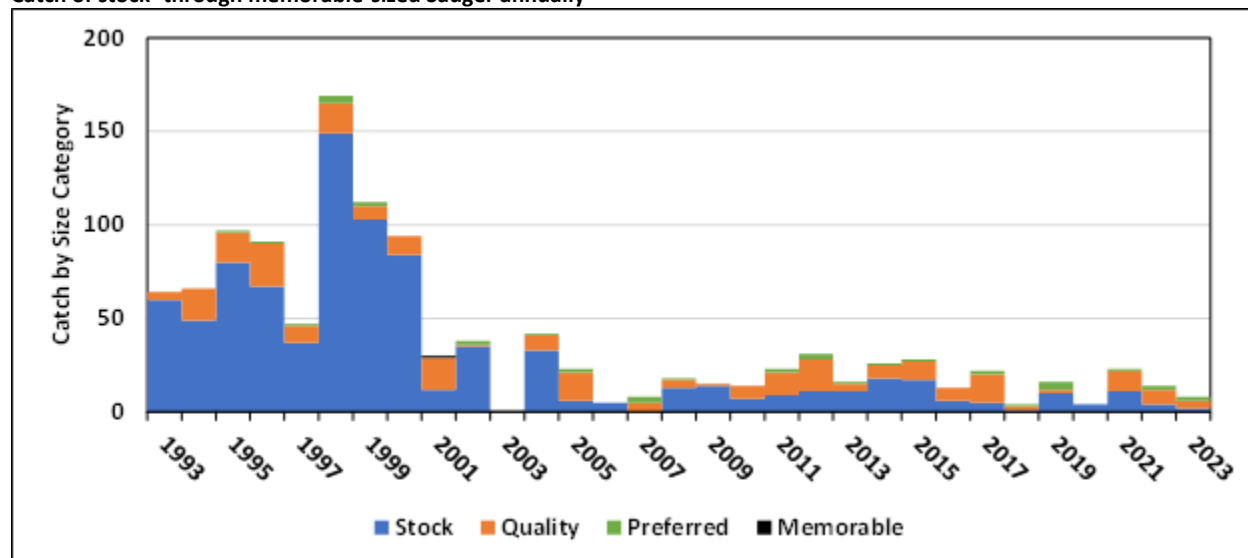
Catch of stock- through memorable-sized Sauger annually

Figure 4.31. Catch of stock- through memorable-sized Sauger 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. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

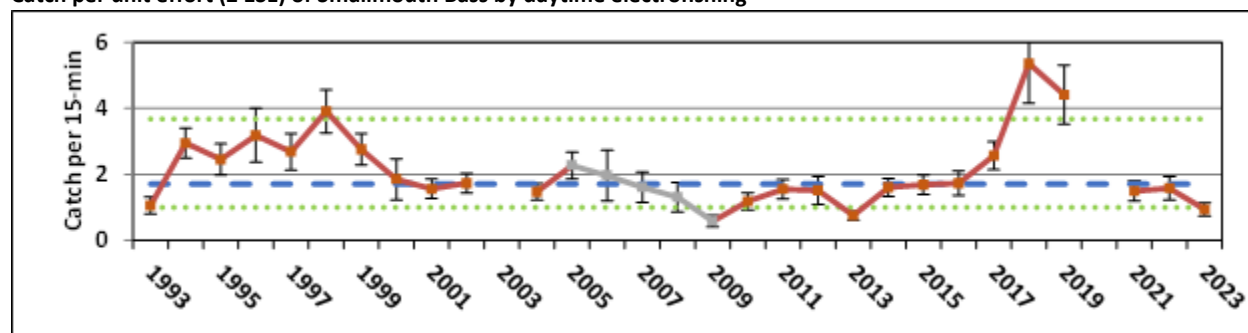
Catch per unit effort ($\pm 1SE$) of Smallmouth Bass by daytime electrofishing

Figure 4.32. Catch per unit effort ($\pm 1SE$) of Smallmouth Bass by daytime electrofishing 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 and 2020 due to limited sampling those years. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. The dotted lines on the CPUE graph represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

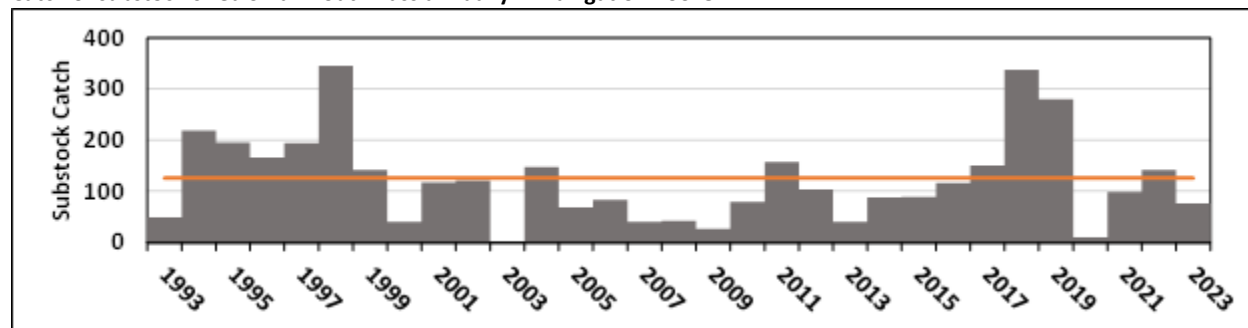
Catch of substock-sized Smallmouth Bass annually in Navigation Pool 8

Figure 4.33. Catch of substock-sized Smallmouth Bass 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. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

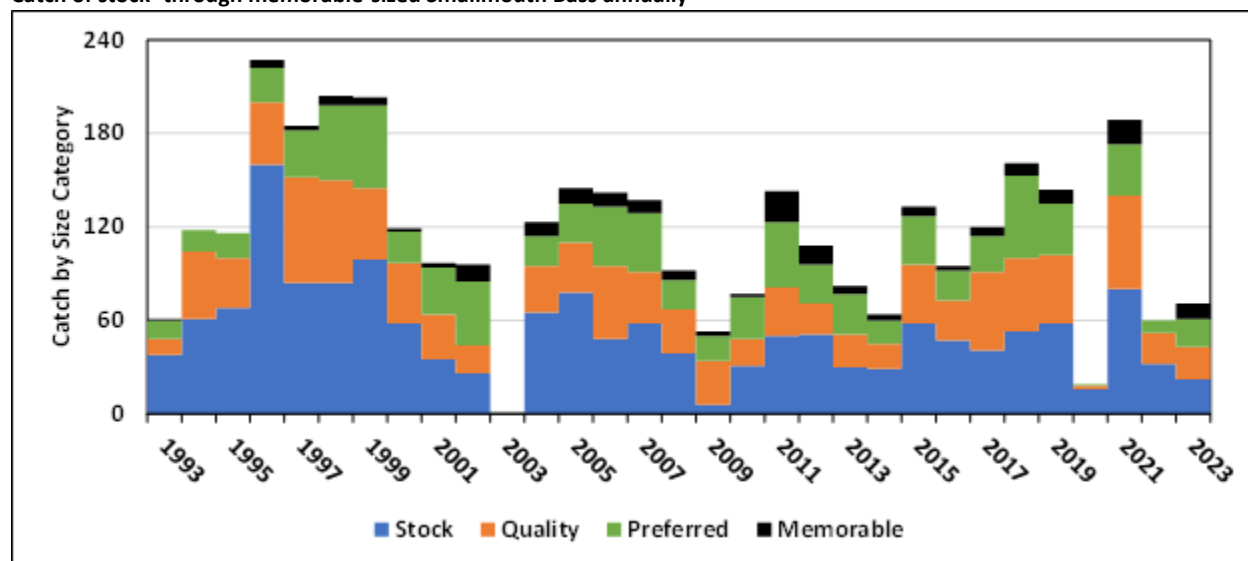
Catch of stock- through memorable-sized Smallmouth Bass annually

Figure 4.34. Catch of stock- through memorable-sized Smallmouth Bass 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. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

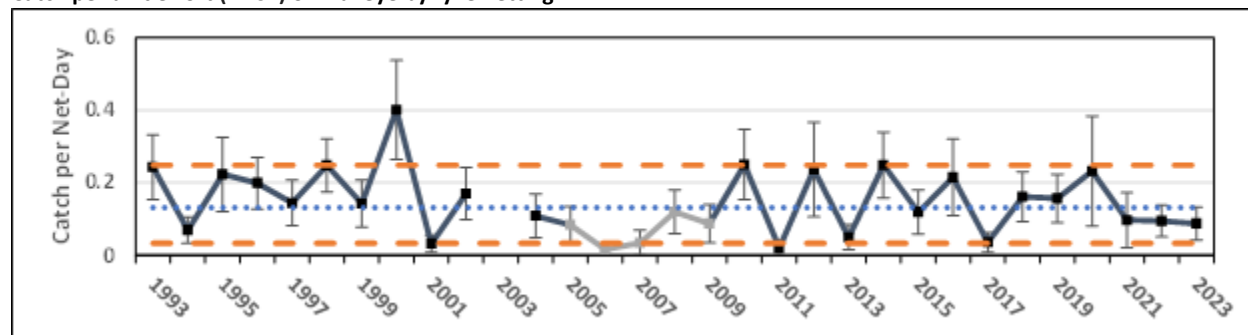
Catch per unit effort ($\pm 1SE$) of Walleye by fyke netting

Figure 4.35. Catch per unit effort ($\pm 1SE$) 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. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. The dotted lines on the CPUE graph represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

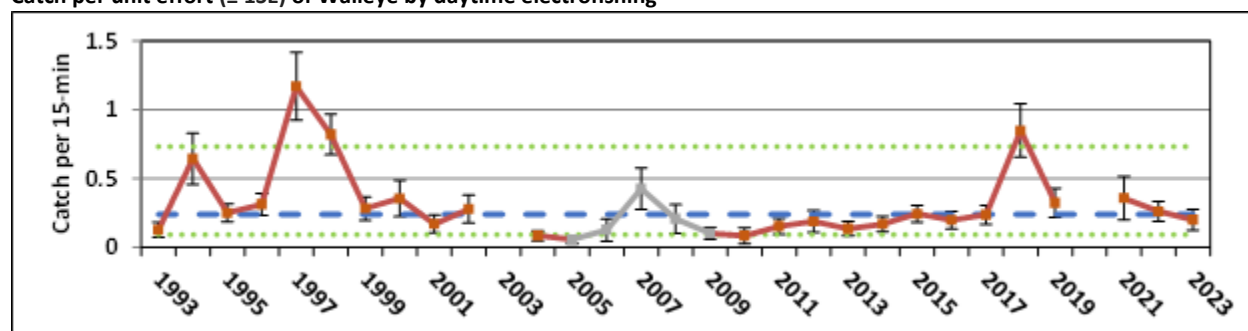
Catch per unit effort ($\pm 1SE$) of Walleye by daytime electrofishing

Figure 4.36. Catch per unit effort ($\pm 1SE$) of Walleye by daytime electrofishing 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 and 2020 due to limited sampling those years. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. The dotted lines on the CPUE graph represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

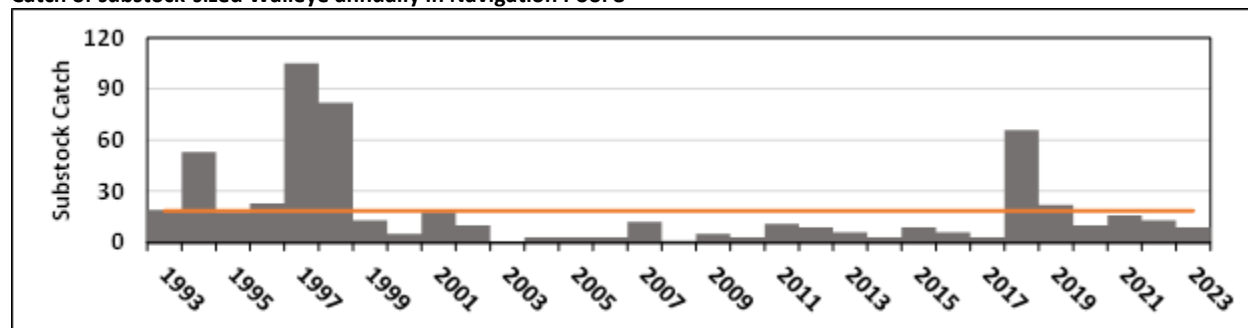
Catch of substock-sized Walleye annually in Navigation Pool 8

Figure 4.37. 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. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

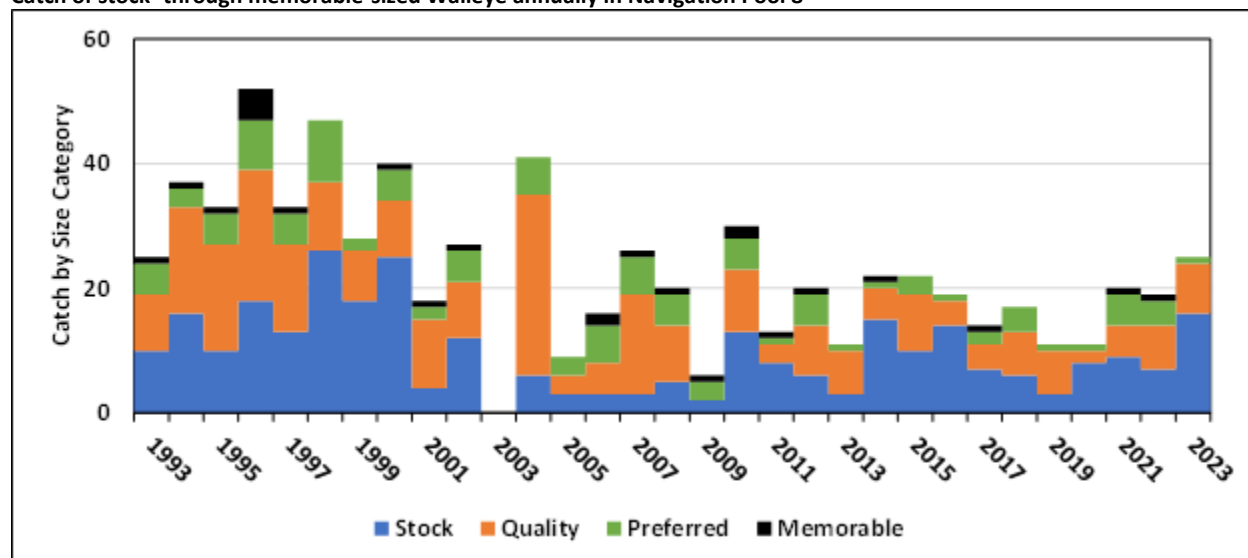
Catch of stock- through memorable-sized Walleye annually in Navigation Pool 8

Figure 4.38. 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. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

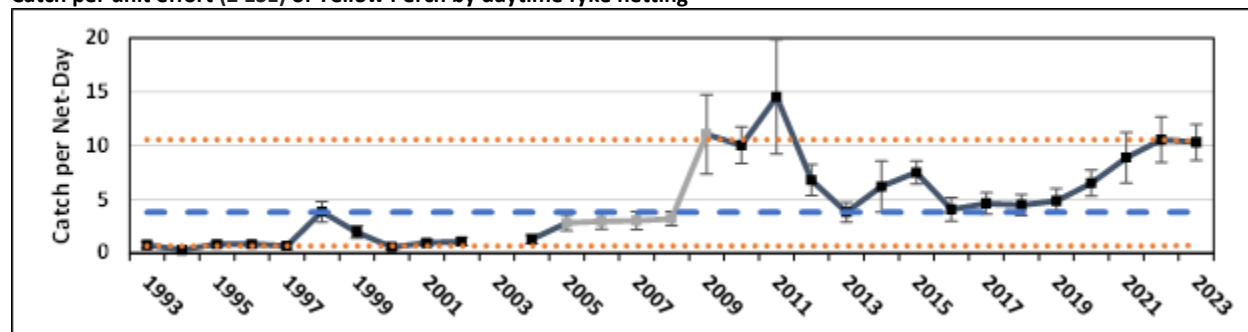
Catch per unit effort ($\pm$ 1SE) of Yellow Perch by daytime fyke netting

Figure 4.39. Catch per unit effort ($\pm$ 1SE) of Yellow Perch 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. Data for 2005-2009 are shaded in gray because period 1 samples were not collected those years. The dotted lines on the CPUE graph represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

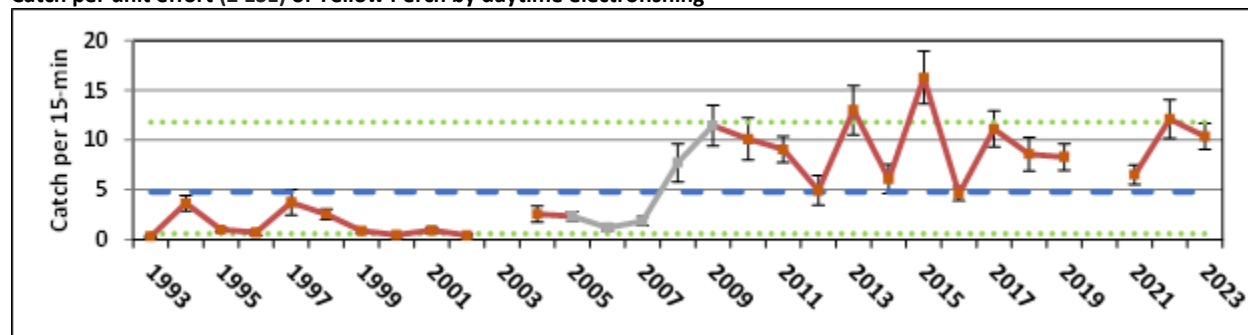
Catch per unit effort ($\pm$ 1SE) of Yellow Perch by daytime electrofishing

Figure 4.40. Catch per unit effort ($\pm$ 1SE) of Yellow Perch by daytime electrofishing 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 dotted lines on the CPUE graphs represent the 10th and 90th percentiles and the long-dashed line represents the long-term average for the period of record (1993-2023).

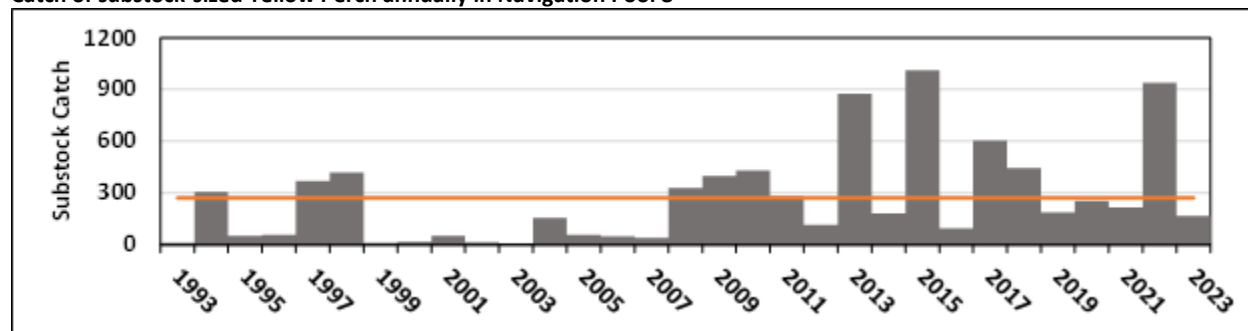
Catch of substock-sized Yellow Perch annually in Navigation Pool 8

Figure 4.41. 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. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.

Catch of stock- through memorable-sized Yellow Perch annually

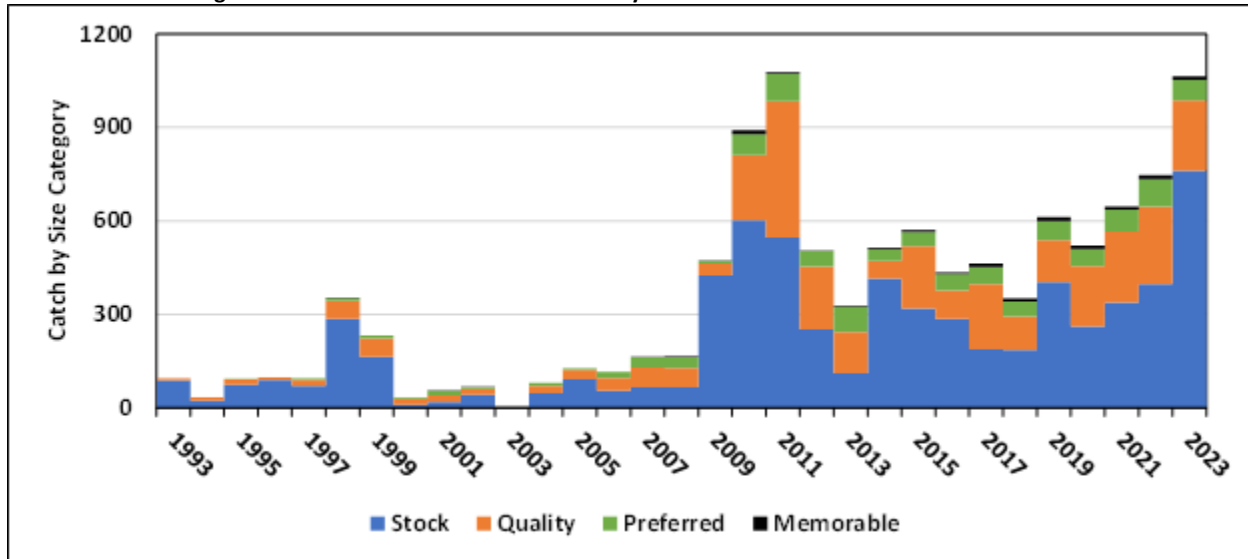


Figure 4.42. Catch of stock- through memorable-sized Yellow Perch annually in Navigation Pool 8 of the Upper Mississippi River by all gears combined from the Upper Mississippi River Restoration Program - Long Term Resource Monitoring Element. Data are omitted for 2003 due to limited sampling that year. Period 1 sampling was omitted from 2005-2009. Electrofishing and trawling data were not collected in 2020 due to COVID-19 restrictions, and numbers are based only on netting.