Upper Mississippi River Pool 8

Long Term Resource Monitoring - 2017 Status Report

An element of the

Upper Mississippi River Restoration Program

Mississippi River Monitoring Field Station

2630 Fanta Reed Road, La Crosse, WI 54603

http://www.umesc.usgs.gov/field_stations/fs2/lacrosse.html

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Introduction

Fish, water quality, and vegetation data are collected each year through the Upper Mississippi River Restoration (UMRR) Program - Long Term Resource Monitoring (LTRM) element. A complete description of the program can be found at: https://umesc.usgs.gov/ltrm-home.html. Personnel from the Wisconsin Department of Natural Resources (WDNR) collect data in Navigation Pool 8 (Pool 8), one of 6 study reaches included in the program. Water quality and fish data have been collected under a stratified random sampling (SRS) framework since 1993 and aquatic vegetation data since 1998. This report summarizes the 2017 dataset in the context of how it relates to the LTRM SRS period of record. We also include herein weather, climate, and hydrograph information that may help explain unique features of the individual annual data sets.

2017 Hydrograph

Methods

Discharge data were obtained from the U.S. Army Corps of Engineers' (Corps) St. Paul District web site (http://www.mvp-wc.usace.army.mil/Data.html) for water information on the Upper Mississippi River (UMR). For 2017, we used discharge estimates from Lock and Dam 8 at Genoa, WI, as we have done starting with the 2013 report. Previously, we had used actual gauge data from Lock and Dam 5, in Winona, MN, but those data are no longer available. This results in using a more local gauge, but having a shorter time series and an unofficial gauging station. The Corps changed the way they serve data in 2017. Daily discharge estimates were replaced with 4-hr estimates which did not match precisely with historic data. Thus, we now report daily mean discharge values, calculated from the 4-hr estimates, for the period 1988-present, and single daily values from 1959-1987. The reporting differences were considered minor enough that we still combined them into a single dataset for analyses.

A historical hydrograph was constructed by computing the mean daily discharge values from the years 1959-2016. The average daily discharge for 2017 was then overlain on the long-term daily mean to observe departure from typical conditions. Additional analyses examined annual, growing season (May–September), and spring flood discharge characteristics. Mean discharge was calculated from daily values, plotted for years 1993-2017 (i.e. LTRM period of record for SRS), and overlain on a plot containing the historic mean, 10th, and 90th percentiles for all years (1959 to 2017). Mean growing season discharge was calculated and plotted similarly to the mean annual discharge. 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 (March through May) in which the discharge exceeded the historic 75th percentile discharge value from those three months. Magnitude was reported as the maximum spring discharge value for each year.

Results

2017 was one of the warmest and wettest years on record for La Crosse, although many of the days with above-average temperature occurred during the winter months. Precipitation, locally, was above normal for much of the first half of the year, but was generally below normal during the second half of the year (source: National Weather Service, http://www.weather.gov/arx/lse2017). May (+3.68"), July (+3.37"), and October (+3.84") were all well above normal for precipitation, but August (-3.23") and September (-2.61") were well below normal. As has been common in recent years, several large precipitation events affected the hydrograph. Water levels were above normal in much of the winter, and spring snowmelt began in late February (Figure 1).

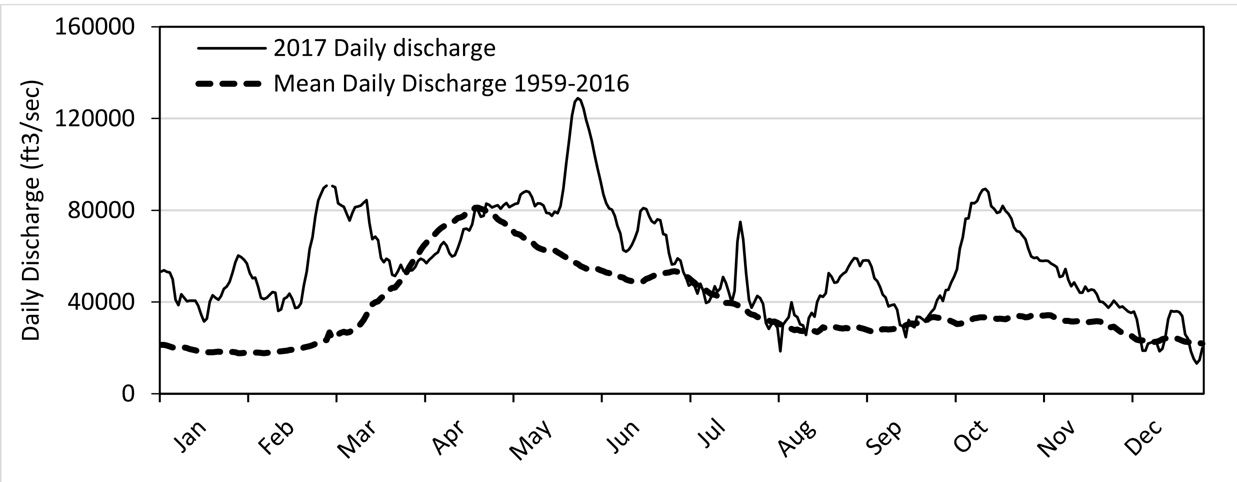

Figure 1. Daily discharge at Lock and Dam 8 on the Upper Mississippi River for 2017 is represented by the solid line. Mean daily discharge by day of the year for 1959-2016 is represented by the dotted line. U.S. Army Corps of Engineers data.

Discharge peaks that occurred in May, June, August, and October were due to large rainfall events in the basin, resulting in the third highest mean annual discharge of the LTRM era (Figure 2), and second consecutive year of very high discharge. Mean growing season discharge, however, was near the 90th percentile, and was the fifth highest for the LTRM period (Figure 3).

Five of the six highest mean annual discharges recorded during the LTRM period of record occurred in the past eight years, along with four of the six highest mean growing season discharges. This contrasts with the 1990's when discharge generally remained close to the long-term averages, and the early 2000's, when discharges were frequently lower than average. These recent extremes of high discharge highlight the importance of continued long-term monitoring on the UMR. Bimodal and polymodal hydrographs have also become more common in the last decade, including fall (2016) and winter (2015) floods.

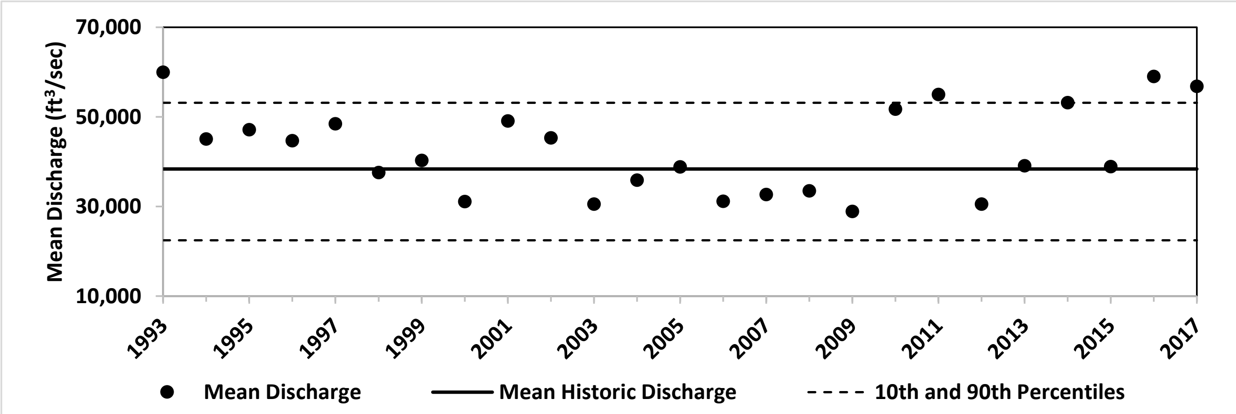

Figure 2. Mean discharge at Upper Mississippi River Lock and Dam 8, by year. Mean annual discharge is represented by the black dots. The solid line represents mean historic discharge for 1959-2017. The dashed lines represent the 10th and 90th percentiles for 1959-2017 discharge. U.S. Army Corps of Engineers data.

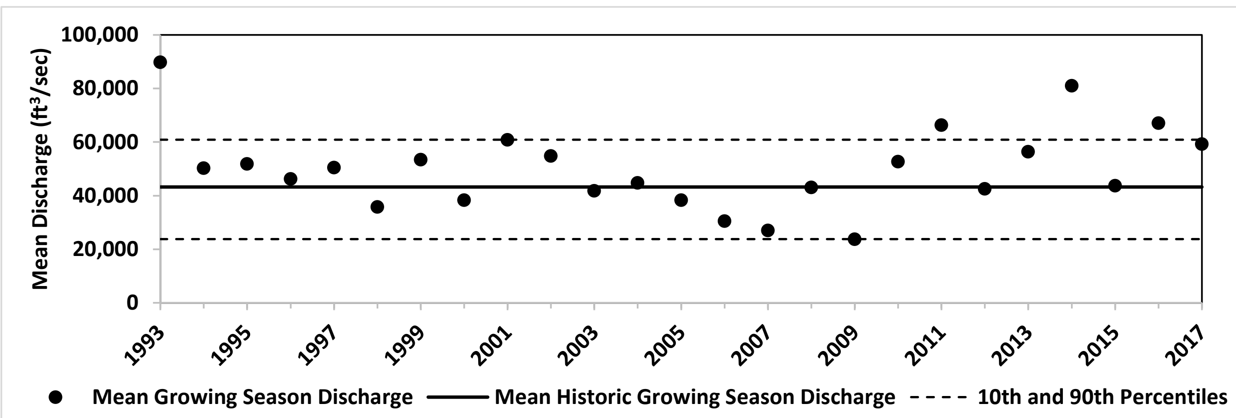

Figure 3. Mean growing season discharge (May-Sept.) at Upper Mississippi River Lock and Dam 8, by year. Mean growing season discharge is represented by the black dots. The solid line represents mean historic growing season discharge for 1959-2017. The dashed lines represent the 10th and 90th percentiles for 1959-2017 growing seasons. U.S. Army Corps of Engineers data.

The 2017 spring flood analysis (Table 1) and hydrograph (Figure 1) reveal that, although the snowmelt occurred in February and March, the spring flood peak occurred in May. During April, when discharges are typically at their seasonal peak, snowmelt discharge had already decreased. Thus, the April portion of the hydrograph remained close to the long-term mean (Figure 1). A large local rainfall event at the end of May contributed to the highest discharges for the year. Water levels were elevated for 50 days during the spring, and the peak discharge was 128,867 cfs, both within normal ranges. However, the May discharge peak resulted in 2017 being another in a recent trend of years where the spring flood was atypical – 2011 was the last year that the timing, duration, and magnitude of the spring flood corresponded with the historic hydrograph and discharge values. These disruptions to timing of flows may impact some biota that cannot adapt well to environmental changes, especially in combination with the high discharges mentioned in the previous section.

Table 1. Spring flood pulse statistics by year during the LTRMP period of record (1993-2017) 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 (1959-2016). 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.

Year	Duration	Timing	Magnitude	Year	Duration	Timing	Magnitude
1993	53	April	116,100	2005	19	April	96,133
1994	21	May	105,983	2006	26	April	103,817
1995	28	May	85,417	2007	18	April	87,500
1996	30	April	137,767	2008	40	May	100,317
1997	40	April	188,533	2009	11	April	83,667
1998	24	April	122,183	2010	26	March	114,150
1999	32	May	110,517	2011	69	April	168,033
2000	0	March	66,617	2012	0	May	77,533
2001	54	April	224,667	2013	50	May	116,117
2002	21	April	119,900	2014	49	May	133,300
2003	23	May	116,883	2015	1	May	78,917
2004	3	April	81,400	2016	17	March	105,450
				2017	50	May	128,867

2017 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 incorporates year round fixed-site sampling (FSS) and quarterly stratified random sampling (SRS). The mixed-model design provides information at both broad spatial scales with low temporal resolution (i.e., SRS) and at small spatial scales with higher temporal resolution (i.e., FSS). SRS tracks conditions at spatial scales corresponding to sampling strata or larger (i.e., whole pool 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 backwater areas with high habitat value. The data used for this report are weighted poolwide median values from SRS sampling. Water temperature and dissolved oxygen (DO) concentrations used in this report were surface measurements taken at 0.20m. Water samples were collected near the surface (0.20m) to quantify total suspended solids (TSS), chlorophyll a, total phosphorus (TP) and total nitrogen (TN). More details on LTRMP water-quality sampling methods can be found in Soballe and Fischer (2004) at:
http://www.umesc.usgs.gov/documents/reports/2004/04t00201.pdf.

More in-depth graphical display of data pertaining to water quality metrics by season, reach and sampling stratum can be found by utilizing the LTRMP Water Quality Graphical Data Browser at: http://www.umesc.usgs.gov/data_library/water_quality/water_quality_page.html.

Results

Water quality in 2017 was strongly influenced by high discharge throughout the year (3rd highest annual and 6th highest growing season discharge, Figures 1-3). Discharge during winter and fall SRS episodes was double the long term average. There were also sustained periods of high discharge in early and late spring as well as late summer. Impacts of high flow on water quality variables are discussed more below in the summaries of the major water quality variables.

Water temperature was near the long term median for winter and summer and near the 75th percentile for spring and fall (Figure 4a). A temperature reversal was noted between the first and second week of spring SRS with cold overnight temperatures driving the change. We are interested in how reversals in temperature may affect timing of fish spawning, larval survival etc. Several reversals may occur in a given season, especially in spring, including warming to >10^{o}C and back to 0^{o}C (including ice formation). Our field station is currently involved with development of proposals that will address effects of abiotic factors, such as temperature and discharge on fish recruitment success.

Water temperature can have direct and indirect effects on large river ecology. Warm water temperatures can result in higher respiration rates, leading to lower oxygen saturation concentrations, which can increase the frequency of hypoxic conditions (Houser et al., 2015; Likens, 2010). Water temperature also influences the rate of photosynthetic production in aquatic ecosystems (i.e. low rates of photosynthetic productivity at very low and very high water temperatures and high rates of productivity at intermediate temperatures). The LTRM SRS data browser does not show any strong trends for temperature. Winter and summer have weak increasing trends, while spring and fall show a weak decreasing trend (pool-wide 1993-2017).

Total suspended solids (TSS) was high in winter (> 90th percentile), between the 25th and 50th percentile for spring and summer and close to the 50th percentile for fall (Figure 4b). While median winter TSS was relatively high at 3.5 mg/l, this is still a pretty low level of TSS, especially when compared to other seasons. Above average temperatures and rainfall (which is uncommon this time of year) increased runoff and therefore discharge. In fact, winter discharge was as high as 71 kCFS which is triple the long term average for this time of year. So it's not surprising winter TSS values were elevated and had the second highest winter pool-wide median for the LTRM period of record. The LTRM SRS data browser shows a strong decreasing trend in pool-wide TSS for spring, summer and fall and a weak decreasing trend for winter (Pool 8, 1993-2017).

High TSS concentration can limit primary productivity by blocking light. It also negatively affects macroinvertebrate respiration and behavior, results in habitat loss, and affects fish by reducing feeding efficiency and smothering spawning habitat (Walters, 1995). Despite having one of the highest discharge years on record, TSS values observed were at or below the long term median in spring, summer and fall. This is likely due to fewer intense rain events locally, and flow from far north in the basin that has clarified as it moved through Lake Pepin, before reaching Pool 8. Additionally, aquatic vegetation levels remained high in 2017, with > 75% of sites being vegetated (see Aquatic Vegetation section).

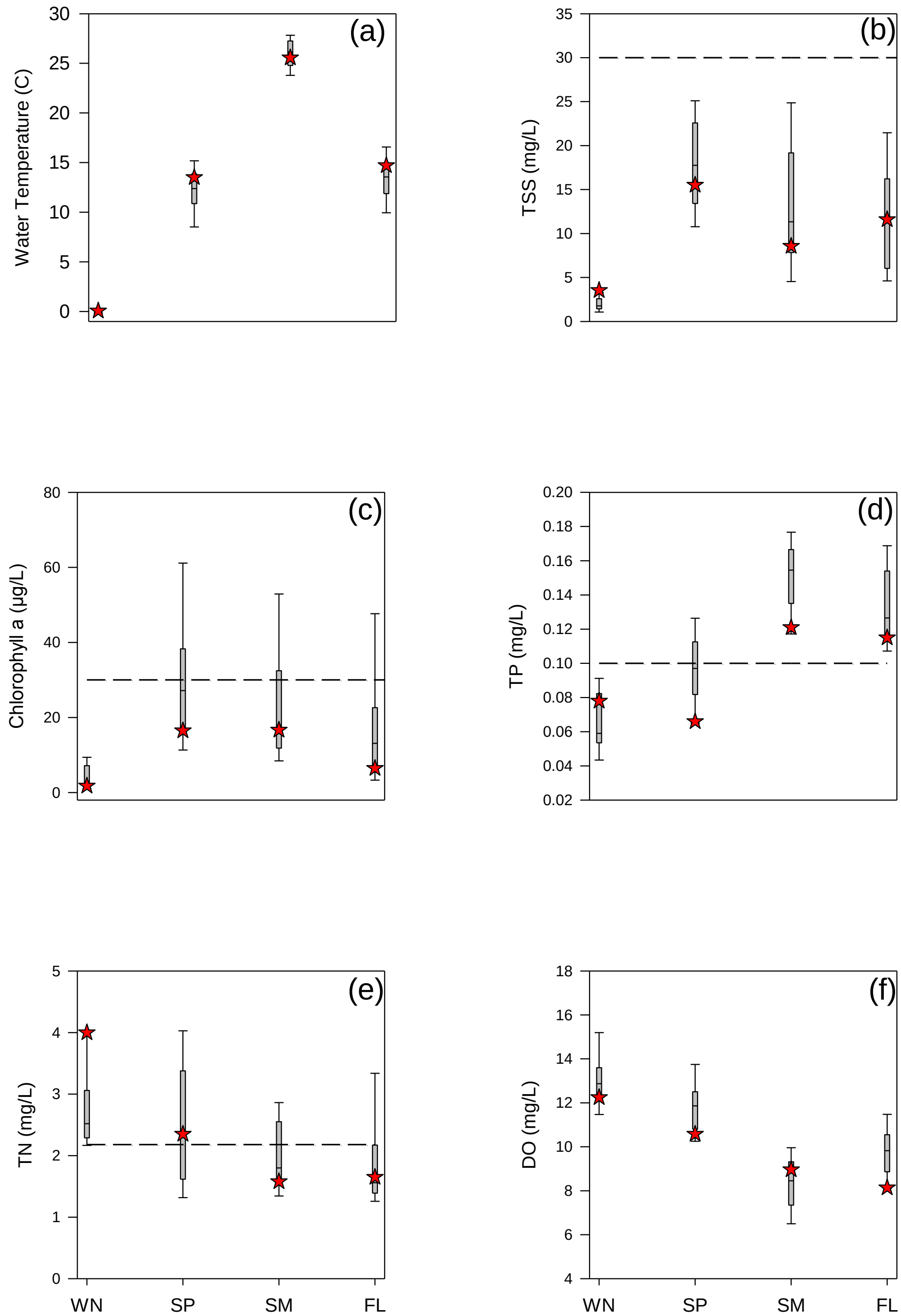

Figure 4. Box plots represent the 10th, 25th, 50th, 75th, and 90th percentiles of the medians by stratified random sampling season for the Long Term Resource Monitoring Program period of record (1993-2017). The star represents the weighted pool-wide median for each parameter by season for 2017. (b) The dashed line represents the upper limit to sustain submersed aquatic vegetation in the Upper Mississippi River from Giblin et al., 2010. (c) The dashed line represents the lower limit of the eutrophic range as defined by Dodds et al. 1998. (d) The dashed line represents the total phosphorus criterion for non-wadeable rivers in Wisconsin as defined by NR 102.06. (e) The dashed line represents upper limit of the range suggested for total nitrogen as defined by the USEPA (2000).

Aquatic vegetation can contribute to the lowering of TSS concentrations, as it slows water velocity, and allows sediment to fall out of the water column. It also stabilizes sediment and reduces sediment resuspension from wind- and boat-generated waves (Madsen et al., 2001). The physical influence that aquatic vegetation has on the river hydrology can create a positive feedback loop that allows more areas to be vegetated, which further lowers TSS (Giblin 2017). TSS concentrations in 2017 were well below the criterion (<30 mg/L) required to sustain submersed aquatic vegetation (SAV) in the UMR during all seasons (Giblin et al., 2010).

Chlorophyll a concentrations were below the long term median throughout the year; these lower concentration are likely a function of dilution, mixing and flushing due to the high and erratic discharge during 2017 (Figures 1, 4c). Chlorophyll a is an indicator of phytoplankton biomass in the water column. As in lakes, light, temperature, nutrients, and hydraulic retention time are the primary factors determining phytoplankton biomass and growth (Houser et al. 2015; Likens, 2010, Soballe and Kimmel 1987).

Median chlorophyll a levels in 2017 were at or below the long term median, with spring and fall having the lowest levels (~25th percentile, Figure 4c). Median chlorophyll a values were also below the eutrophic range (>30 µg/L, from Dodds et al., 1998) during 2017. Eutrophication is still a major water quality issue in the UMRS, and while Pool 8 values fell below the eutrophic range for chlorophyll a, this may not accurately characterize the trophic state of Pool 8. The sustained high discharge (i.e. decreased retention time) during 2017 likely (or at least in part) led to lower chlorophyll a concentrations, due to dilution and flushing of phytoplankton. The LTRM SRS browser data does not show any pool-wide- seasonal trends for chlorophyll a from 1993-2017.

Two other factors may be affecting suspended algae productivity in Pool 8. First, high densities of SAV may be resulting in allelopathy, thereby suppressing algal growth. Backwaters tend to be dominated by coontail, Elodea and Eurasian milfoil - all three are known to produce alleopathic toxins (Hilt and Gross 2007). Field station staff have made anecdotal observations of very clear water in backwaters even though nutrients (NOx and SRP) are abundant. Secondly, we observed very few algal blooms from cyanobacteria (e.g. Microcystis, Aphanizomenon), which is not surprising because these blooms tend to be more prevalent during periods of low discharge with warm water temperatures.

Phosphorus is an essential plant nutrient that can limit the biomass of phytoplankton and aquatic macrophytes in aquatic ecosystems. Excessive phosphorus loading can result in increased biomass of phytoplankton, rooted and free-floating plants, increased incidence of fish kills, reduction in species diversity, and reduction in perceived value of a water body (Smith and Schindler, 2009, Giblin et al. 2014). Total phosphorous levels (TP) were near the 75th percentile for winter, near the 10th percentile in spring and summer and between the 25th and 50th percentile for fall (Figure 4d). The LTRM SRS data browser shows a fairly strong decreasing trend in TP for winter and fall and a weak decreasing trend for spring and summer (pool-wide, 1993-2017).

A significant fraction of TP inputs come adsorbed to the TSS load. Therefore, the concentration of TP tends to track well with TSS, and is also tied to the severity of rain events (heavy rain events causing more erosion/runoff in the watershed), which results in increased sediment delivery to the river. It was not surprising to see the lower TP levels in spring, summer and fall given the conditions we experienced (i.e. high discharge and low-TSS water being delivered to Pool 8). Winter TP was elevated, likely due to unseasonably warm weather melting snow, combined with periods of rain. Median TP levels were well below the Wisconsin TP criterion (0.10 mg/L) for non-wadeable rivers (Wisconsin administrative code NR 102.06) in winter and spring, and just above in summer and fall. It is noteworthy that even though median summer phosphorous levels were near the 10th percentile for the LTRM period of record, they still exceeded the Wisconsin TP criterion.

Elevated phosphorous levels are often attributed to inputs from point and non-point source pollution (e.g. municipal treatment plants and agriculture runoff). There can also be significant phosphorous inputs from sediment microbial activity, especially in backwaters experiencing anoxic conditions during the warmer months. This is known as anoxic sediment release of phosphorous. High discharge may have limited the amount of anoxic sediment release in 2017, as very few sites had anoxic conditions.

Nitrogen, like phosphorous is an essential plant nutrient that can limit the biomass of phytoplankton and aquatic macrophytes in aquatic ecosystems. Excessive delivery of nitrogen (mainly from agriculture) in the form of nitrate to groundwater and surface waters has been associated with a number of negative consequences for human and ecosystem health (Wolfe and Patz, 2002). Nitrogen concentration tends to increase with increasing discharge, as non-point input from agriculturally dominated tributary watersheds is delivered to the UMR (Goolsby et al., 2000).

Total nitrogen (TN) was high in winter (90th percentile), close to the median in spring and fall, and at the 25th percentile in summer (Figures 4e, 5). In 2017, TN was near or below the upper concentration recommended by the United States Environmental Protection Agency (USEPA) for ecosystem health (0.6-2 .18 mg/L) during spring, summer and fall, but double the upper limit in winter (USEPA, 2000). Trends for TN are mixed. The LTRM SRS data browser shows a strong increasing trend in winter, a weak decreasing trend in spring and summer, and a weak increasing trend in fall (pool-wide 1993-2017).

TN levels in 2017 were lower than expected for such a high precipitation/discharge year. The 2016 hydrograph and mean discharge were very similar to 2017, but had much higher TN; 2016 spring and summer medians were at the 75th percentile, while fall far exceeded the 90th percentile, with a median of 4.35 mg/l. Winter values were nearly identical (90th percentile and ~4 mg/l). It's not clear why TN in 2017 was so much lower in spring, summer and fall.

The opposite trends between TP and TN (i.e. low TP: high TN) are not unusual; nitrogen is known to track closely with discharge. Watershed management practices have had little success is lowering nitrogen delivery to rivers and ultimately the Gulf of Mexico. Kreiling and Houser (2016) found that TN and/or nitrate levels in six UMR tributaries were mostly stable or increasing between 1991 and 2014. Further investigation into the variation observed between two apparently similar years, as well as the strong increasing winter trend, is needed.

Adequate dissolved oxygen (DO) is critical to sustain aquatic life. DO concentration can be reduced through decomposition of organic material from point and non-point sources, plant and animal respiration, and demand from accumulated sediment. Median DO was near the 25th percentile in winter, between the 10th and 25th percentile in spring, between the 50th and 75th percentile in summer, and at the 10th percentile in fall (Figure 4f). LTRM SRS data browser shows a weak increasing trend in winter, a weak decreasing trend in spring and fall, and no trend for summer (pool-wide 1993-2017).

While median DO was lower in all seasons except summer, it did not reach critical levels (below 5 mg/l) for many biota such as fish, mussels or inverts. Erratic hydrographs with steep decreases in discharge (like we experienced in 2017), can result in water level fluctuations which end up delivering ("flushing") organic matter with high biological oxygen demand (BOD) from shallow marshes and other floodplain areas to the water column. As this organic matter is broken down by microbes it consumes DO, lowering the saturation level.

			TEMP	DO	COND	pH	TURB	SS	VSS	CHL	TN	NOX	NHX	TP	SRP
Pool 8	Winter	POOL	.	.	.	.	.	.	.	.	H	H	.	.	.
		MC	.	.	.	.	H	.	.	.	H	H	.	.	.
		SC	.	.	.	.	.	.	.	.	H	h	.	.	.
		BWC	.	.	.	.	.	.	.	.	.	h	.	.	.
		IMP	.	.	.	.	H	.	.	.	h	h	.	.	.
	Spring	POOL	.	.	.	.	.	.	.	.	.	.	l	.	.
		MC	.	.	.	.	.	.	.	.	.	.	.	.	.
		SC	.	.	.	.	.	.	.	.	.	.	l	.	.
		BWC	.	.	.	.	.	.	.	.	.	.	.	l	.
		IMP	.	.	.	.	.	.	.	.	.	.	.	.	.
	Summer	POOL	.	.	.	.	.	.	.	.	.	.	.	.	.
		MC	.	.	.	.	.	.	.	.	.	.	.	.	.
		SC	.	.	.	.	.	.	.	.	.	.	.	.	.
		BWC	.	.	.	.	.	.	.	.	.	.	.	.	.
		IMP	.	.	.	.	.	.	.	.	.	.	.	.	.
	Fall	POOL	.	.	.	.	.	.	.	.	.	.	.	.	.
		MC	.	.	.	.	.	.	.	.	.	.	.	.	.
		SC	.	.	.	.	.	.	.	.	.	.	.	.	.
		BWC	.	.	.	.	.	.	.	.	.	.	.	.	.
		IMP	.	.	.	.	.	.	.	.	.	.	.	.	.

Figure 5. Comparison of 2017 water quality conditions to normal conditions (from UMRR website https://www.umesc.usgs.gov/reports_publications/ltrmp/water/2017_annual_unusual.html). Data acquired over a 15-yr period (1994-2009; data missing in 2003) was used to determine annual 95% upper confidence limits (UCL) and 95% lower confidence limits (LCL) of the mean for each variable/reach/episode/stratum. Estimates of the 95% upper and lower confidence limit for the year of interest (e.g., 2010; a year outside the 15-yr period), along with the median, were compared to the 15-yr annual extremes to determine unusual conditions. Estimates where the median was higher than the highest annual 15-yr UCL or lower than the lowest annual 15-yr LCL were "low" (l) or "high" (h), respectively. Estimates where the LCL was higher than the highest annual 15-yr UCL or the UCL was lower than the lowest annual 15-yr LCL were "very low" (L) or "very high" (H), respectively. (.)=normal

This "flushing" from water level fluctuations can at times deplete DO levels to the point of causing fish kills, especially in summer when water temperatures are high (water holds less DO as it warms) and microbial respiration rates increase. Biologists from the Mississippi River Team in La Crosse, WI, attributed the low summer DO and associated fish kills to a steep drop in discharge in July of 2016. Investigations to explore management actions that could potentially temper conditions in these backwaters to avoid future fish kills may warrant investigation.

Ice and snow thickness can affect the concentration of DO in the underlying water column by reducing available light and thereby suppressing photosynthetic activity. Median ice thickness was between the 50th and 75th percentile, while snow depth was near the 10th percentile (Figure 6).

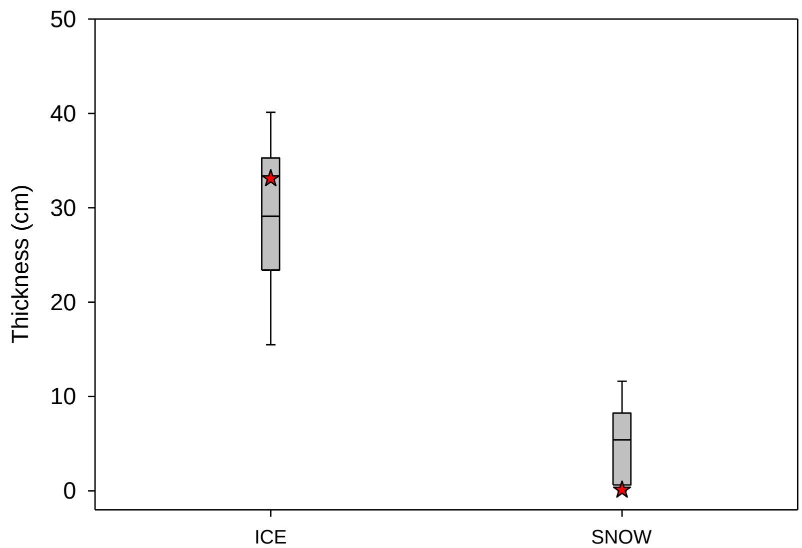

Figure 6. Box plot represents the 10th, 25th, 50th, 75th, and 90th percentiles of the medians for winter ice thickness and snow thickness above the ice sheet during winter for the Long Term Resource Monitoring Program period of record (1993-2014). The star represents the weighted pool wide median for each parameter for the winter of 2017.

The ice and snow conditions during winter 2017 appear to have been suitable for light transmission as median DO during winter was 13.01 mg/l and only a few sites had DO below 5 mg/l. The low DO sites were largely in Blue Lake, an isolated backwater that is often hypoxic in winter, and the remainder were shallow sites with little available water depth below the ice. In a year with such low snow cover we would expect to see areas supersaturated with DO (due to the increased light available to SAV, and algae). Oxygen supersaturation has been implicated as the cause of under-ice fish kills in Pool 8 as well as other pools. It is likely that the high discharge during winter kept water exchange rates high enough to not allow for DO concentrations to reach excessive levels.

2017 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 (www.umesc.usgs.gov/ltrmp/stats/statistics.html). The boat is anchored within 10 m of site coordinates. Emergent species, rooted-floating-leaf species and non-rooted floating leaf species are assigned cover scores based on their abundance in a 2-meter ring around the boat. At each site, submerged 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. Vegetation caught on the rake is scored as "plant density" using a six-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 number 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.

Specific features of the Pool 8 aquatic vegetation in 2017 are based on data spanning 1998 – 2017, downloaded from the LTRM graphical data browser at: (https://www.umesc.usgs.gov/data_library/vegetation/graphical/veg_front.html).

Results:

We conducted surveys at all 450 sites between 15 June and 8 August in 2017 (shown in Appendix A). Two sites were located on land (one in the connected backwater stratum and one in the side channel stratum) and were excluded from calculations.

Long-term patterns in vegetation abundance

Since LTRM probabilistic monitoring began in 1998, the prevalence of the three major vegetation life forms (submersed, rooted floating leaf, and emergent) have increased in Pool 8 (Figure 7).

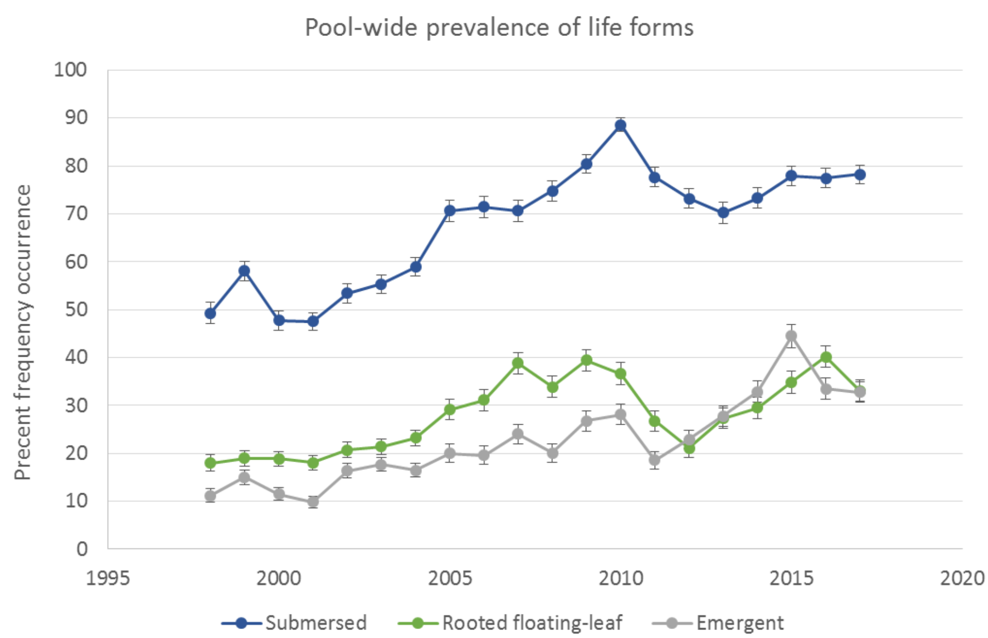

Figure 7. Prevalence of the three vegetation life forms over all 20 years of LTRM probabilistic monitoring (±SE).

The “total aquatic plant index” is the sum of percent frequency occurrence of submersed, rooted floating-leaf, and emergent vegetation (Figure 8) and has also increased considerably. Because all three life forms can overlap in distribution, this index can exceed 100%. The 2017 index value (~144%) was one of the highest values for this metric in the 20 years of monitoring. The peak in 2015 was largely driven by high wild rice (*Zizania aquatica*) abundance that year.

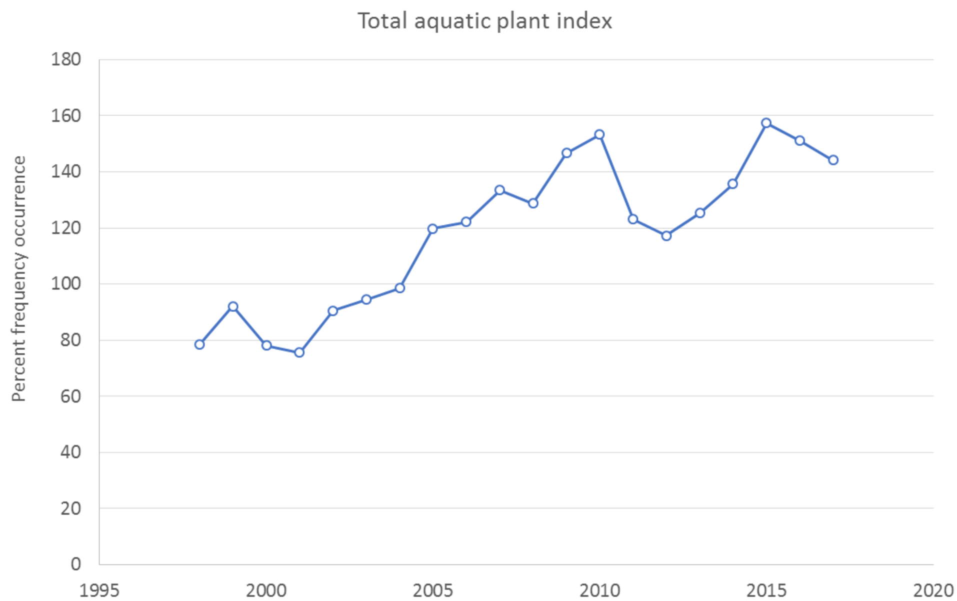

Figure 8. Total aquatic plant index over time is annual, summed percent frequency occurrence of the submersed, rooted floating-leaf, and emergent life forms. Because more than one life form can occur at the same site, the index can exceed 100%.

Aquatic vegetation in the LTRM strata

Vegetation abundance varied considerably between strata, with slow-moving and still waters (the backwater isolated, backwater contiguous, and impounded strata) generally supporting more vegetation than moving waters (side channels and the main channel borders) (Table 2). This is consistent with previous years.

As described in other sections of this report, both 2016 and 2017 were years of high average discharge through most of the sampling season. This did not, however, appear to negatively affect the abundance of most aquatic vegetation. The prevalence (percent frequency occurrence) of SAV remained relatively high, at 78.2% (Figure 7) in 2017.

Percent frequency occurrence of the specific life forms was also similar to 2016 observations (Table 3). The Pool 8 aquatic vegetation community is composed primarily of native species, with only locally abundant invasive species. An increase in aquatic vegetation abundance since ~2002-2003 has been coupled with a decrease in suspended sediments (clearer water), a subtle decrease in nutrient concentrations, and decreasing abundance of invasive Common Carp (see fisheries section). The general indication is that ecological conditions of Pool 8 have improved markedly since the early 2000s.

Table 2. Summary of site distribution among strata for aquatic vegetation sampling in 2017. 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.

Stratum	Number of sites	Depth (m) Average (±SD)	% Vegetated
Backwater connected (BWC)	109	0.71 (0.55)	94.5%
Backwater isolated (BWI)	20	0.62 (0.19)	100.0%
Impounded (IMP)	185	1.27 (0.54)	88.6%
Main channel border (MCB)	70	2.03 (1.52)	34.3%
Side channel (SC)	64	1.56 (0.96)	37.5%

Table 3. Pool-wide mean prevalence of vegetation and specific life forms from 2015 - 2017 showing relative stability (also see Figure 7). All values except non-rooted floating are weighted by stratum to account for sample inclusion probability (https://www.umesc.usgs.gov/ltrmp/stats/means.html). Non-rooted floating values are not available on the browser. "Vegsum" is the total aquatic plant index, the sum of submersed, rooted floating-leaf, and emergent life forms percent frequency observed.

	2015 Percent frequency occurrence	2016 Percent frequency occurrence	2017 Percent frequency occurrence
Submersed	77.90%	77.4%	78.2%
Rooted floating	34.90%	40.2%	33.1%
Emergent	44.50%	33.5%	32.8%
Non-rooted floating *	20.90%	28.0%	25.3%
Filamentous algae	38.50%	36.2%	36.9%
Vegsum	157.30%	151.1%	144.1%

The relative abundance of submersed, emergent, and rooted floating-leaf species varied by stratum (Figure 9), reflecting habitat-based variation in a number of interacting drivers, especially water velocity and light availability (e.g. Kreiling et al. 2007). For example, main channel and side channel areas are characterized by much higher water velocity than backwaters, and the impounded area is intermediate in terms of water velocity.

A portion of the increase in aquatic vegetation over time is attributable to two native species of special interest in the ecology of Pool 8 - wildcelery (*Vallisneria americana* Michx.), and wild rice (*Zizania aquatica* L.). Wildcelery is a predominantly clonal, perennial plant, and has high specific value as forage for canvasback (*Aythya valisineria* Wilson) and other migrating waterfowl. Wild rice, an annual aquatic grass, can also be an important source of food and cover for wildlife. Long-term data show considerable increases in the prevalence of both species since 1998 (Figure 10). Prior to 2009, wild rice was only detected occasionally in surveys. Since then, it has increased to be ~5-6 times more abundant than it was from 1998 – 2007, and the most frequently detected emergent species in Pool 8 LTRM surveys.

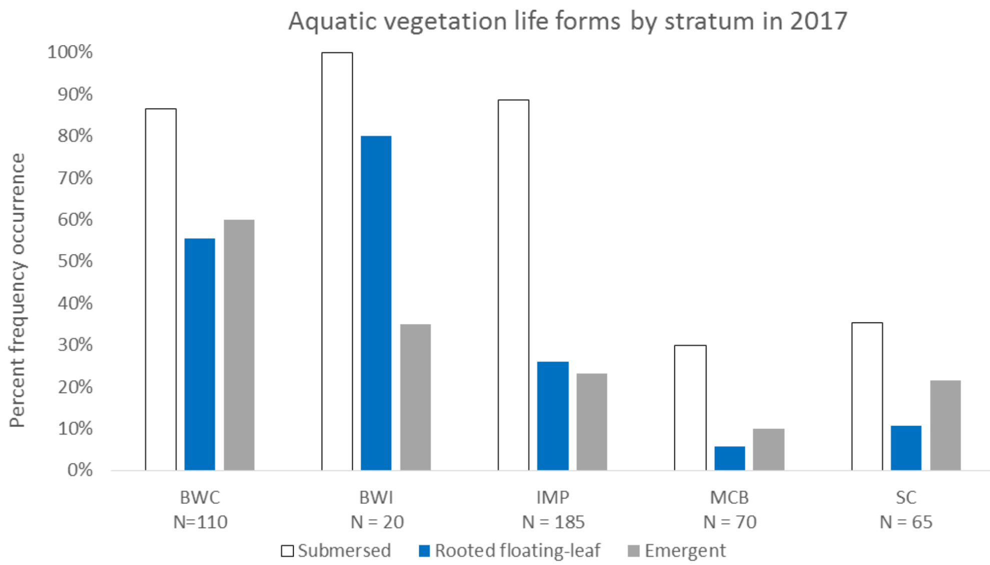

Figure 9. Percent frequency occurrence (prevalence) of vegetation types by stratum.

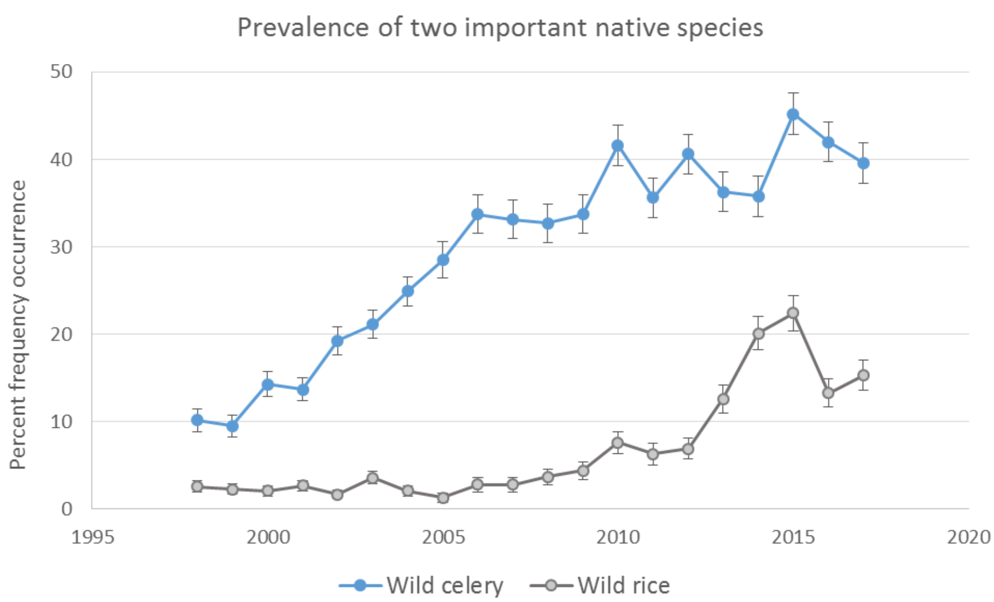

Figure 10. Positive trends in the detection of wildcelery and wild rice (pool-wide means) in Pool 8 over the 20-year period of LTRM monitoring.

Wild rice is now a substantial contributor to the total vegetation index (Figure 8). The highest recorded abundance of both of these native species occurred in 2015. Notably, the 2016 and 2017 prevalences of wild rice were approximately 35% lower than its maximum value in 2015. A possible explanation for this was high water during both spring periods when rice stems were elongating to reach the surface; in both years the rice stalks were very long and delicate (personal observation). We also observed maturation of wild rice seeds in October of 2017, approximately 2 months later than in the 2015 season.

Two invasive species, Eurasian watermilfoil (*Myriophyllum spicatum*) and curly pondweed (*Potamogeton crispus*) occur at ~10-30% of Pool 8 sites annually (Figure 11), but have not increased as dramatically as the native species described above, or as much as the total vegetation index. Although sometimes locally abundant, they rarely appear to exclude native vegetation at the site level, and are virtually never the only species detected at a site. The maximum biomass of *P. crispus* occurs in early- to mid-May, and it has senesced considerably by the time summer surveys are conducted. Due to its off-set phenology, the species is under-represented by approximately 3-fold in summer surveys (Drake et al. 2017).

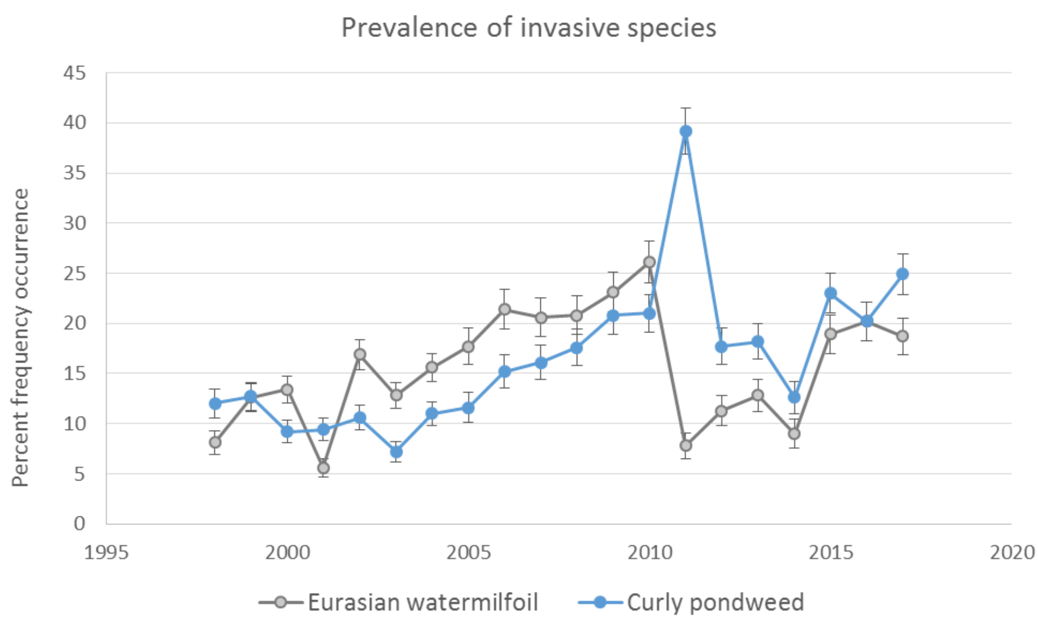

Figure 11. Prevalence of the two common invasive species in Pool 8 over LTRM monitoring.

A total of 34 plant species (excluding algae) have been identified in Pool 8 over the course of LTRM monitoring. At individual vegetated sites, 4-8 species are generally detected. The maximum number of species found at a single site in 2017 was 19, including filamentous algae.

The profusion of algae in freshwater systems is associated with eutrophication, a major concern for managers and users of Pool 8 and the greater Upper Mississippi River. Filamentous algae is often found in dense mats or clinging to vegetation, and late each summer blue-green algae appear as patchy films. Mats of filamentous algae are included in the observation of algae in vegetation surveys (it is given a rake score when found in abundance). The prevalence of algae has varied considerably over time (Figure 12), but has not clearly tracked increases in vegetation.

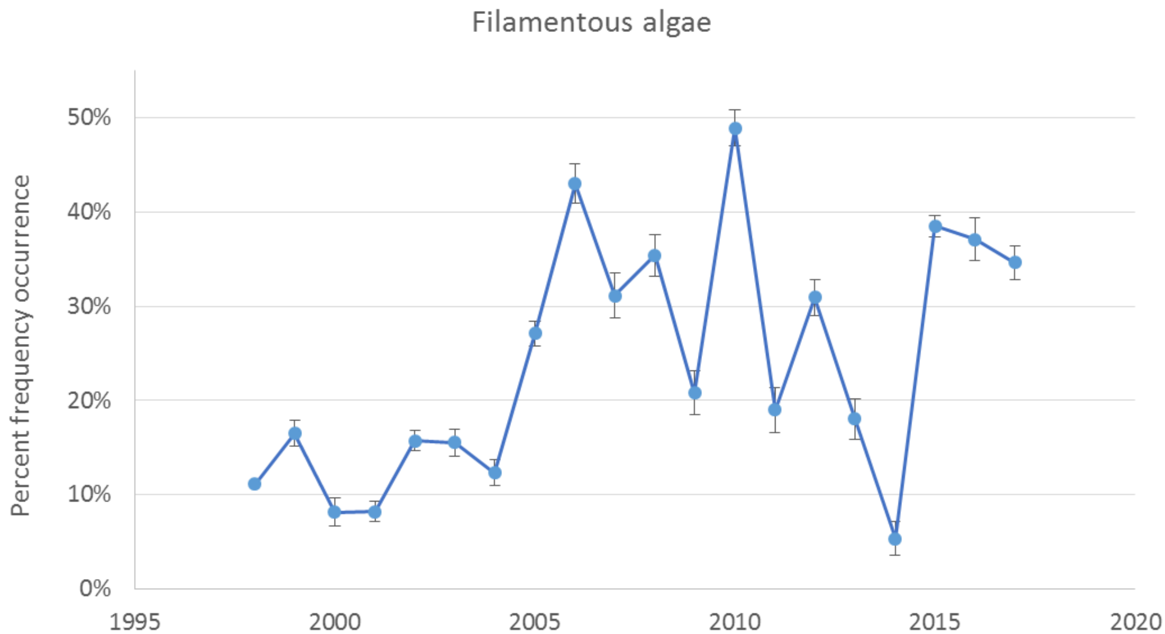

Figure 12. Prevalence of filamentous algae over the entire period of LTRM monitoring.

2017 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 randomized sampling scheme and stratification based on broad habitat features. Fish sampling is conducted within three consecutive six-week episodes, from June 15 to October 31, to ensure both temporal, as well as spatial, interspersion of the sampling gear deployments. More detail on LTRM fish sampling can be found in Ratcliff et al., 2014 at: https://pubs.usgs.gov/mis/ltrmp2014-p001/pdf/ltrmp2014-p001.pdf.

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: http://www.umesc.usgs.gov/data_library/fisheries/graphical/fish_front.html.

Routine data analyses for overall fish community data include species richness, total catch by species, and community composition (presence/absence). Catch per unit effort (CPUE) and frequency of occurrence are calculated for all species, and proportional stock density (PSD) is calculated for species of interest. Proportional Stock Density (PSD) is a measure of species size structure. This metric is a ratio (expressed as percentage) between the number of quality-sized or larger individuals and stock-sized individuals. Stock and quality size designations vary by species, and are defined in published manuscripts (see the LTRM Fish Life History Database for details, which is available at: https://umesc.usgs.gov/data_library/fisheries/fish_page.html). This life history database also contains a table with allometric growth information that allows conversion of length data to mass, and, thus, biomass computations, which yield additional insight into fish community characteristics.

This report summarizes sampling effort, overall catch rates and species richness, as well as abundance and biomass summaries, and data on species of special concern. We also report any Asian carp collections and other anecdotal observations on the fish community. Shannon-Wiener Diversity Index (Zar 1984) scores were computed from day electrofishing collections to indicate fish community diversity relative to previous years. CPUE, mass per unit effort (MPUE), and PSD trends from day electrofishing data are provided for ten common sport fish of interest to anglers and fish managers.

Data were omitted for 2003 in all cases because of reduced sampling that year. Also, catches of fish from daytime electrofishing on wingdams and several gears at fixed tailwater sites are reported in total catch and species richness, but are excluded from CPUE calculations because these strata were considered too small and unique for proper stratification of sampling effort. CPUE values for the individual strata, including wingdams and tailwater fixed sites, are available on the Fish Graphical Data Browser at the link provided above.

Results

All scheduled fish collections were made in Periods 1 and 2 for 2017, but high discharges throughout Period 3 prevented us from collecting tailwater trawl samples and three of four scheduled wingdam electrofishing runs. Thus, 263 of 270 allocated samples were completed for the year.

The planned sampling allocation among gear types has remained stable for many years. Sampling effort was highest for daytime electrofishing (81 collections), followed by mini fyke nets (66 collections), and fyke nets (48 collections). Effort was greatest in the contiguous backwater stratum (84 collections), with side channel (60 collections) and main channel border (48 collections) also receiving considerable effort. Please note that the strata names imply habitat features, but a wide variety of habitat conditions may exist within each stratum.

Total catch in 2017 was 60,112 fish, which is the highest total catch ever recorded in Pool 8 LTRM sampling. The catch per sample value was, therefore, also the highest that has occurred during the stratified random sampling (SRS) era (Figure 13). Mini fyke nets (42,809) and day electrofishing (13,655) were particularly effective, providing almost 94% of the total catch. Species richness in 2017 was 68, the highest value since 2004. This bears watching, as species richness in the 2000’s has generally been slightly lower than in the 1990’s.

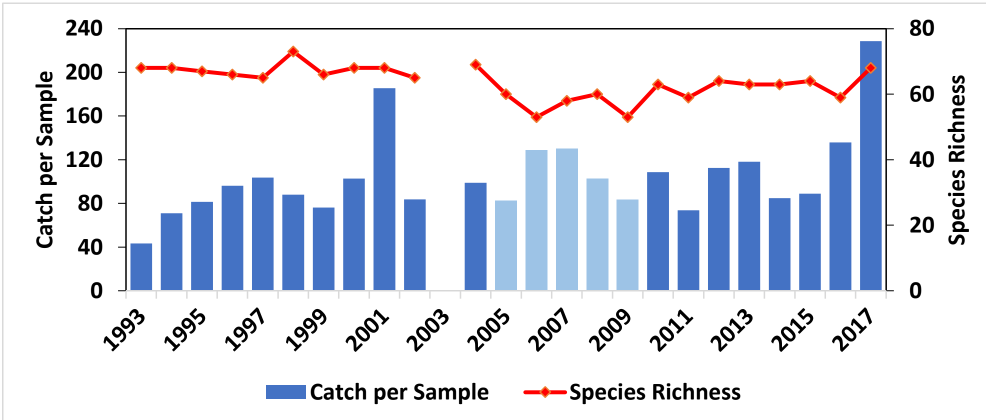

Figure 13. Catch per sample and annual species richness for Upper Mississippi River Restoration Program – LTRM fish collections in Pool 8 of the Upper Mississippi River. Data represent samples collected with daytime electrofishing, fyke nets, mini fyke nets, large and small hoop nets, and otter trawls. Data are omitted for 2003 due to limited sampling that year. Period 1 (June 15 – July 31) was not sampled from 2005-2009 (lighter shaded bars).

Weed Shiner (30,522), Bluegill (14,868), Largemouth Bass (2,057), Emerald Shiner (1,171) and Shorthead Redhorse (1,141) were the top 5 species, in order of catch, in 2017 (Figure 14a). These top five species comprised 83% of the catch. Yellow Perch (1,067) was the only other species represented by over 1,000 individuals in the catch.

For biomass (Figure 14b), Common Carp (794 kg) ranked first in the catch, followed by Shorthead Redhorse (318 kg), Flathead Catfish (271 kg), Bowfin (238 kg) and Freshwater Drum (212 kg). Other "heavyweights" in the catch were Bluegill, Largemouth Bass, Silver Redhorse, Channel Catfish, Golden Redhorse, and Northern Pike, all of which yielded over 100 kg. Numerically dominant Weed Shiner yielded only about 0.5% of the total biomass.

Historically, 37 species have been detected in Pool 8 LTRM samples every year since SRS began in 1993, and an additional 25 species have been detected in at least half of the years. Those numbers held true in 2017, as well. Twenty nine species have been detected in 12 or fewer years. Of that group of relatively rare species, we sampled the following in 2017 (year last detected in parentheses): Banded Darter (2015), Brown Bullhead (2015), Troutperch (2015), Iowa Darter (2013), Northern Hog Sucker (2014), Pirate Perch (2016), Lake Sturgeon (2015), Yellow Bass (2015), and Black Buffalo (2004, the only other year it was sampled). We caught single specimens of the following species in 2017: Blue Sucker, Black Buffalo, White Crappie, Lake Sturgeon, Yellow Bass, Black Bullhead, Silver Chub, Iowa Darter, Northern Hog Sucker, and Largescale Stoneroller. Fewer than 10 individuals were sampled for an additional 17 species. Thus, about 38% of the species detected were very uncommonly encountered.

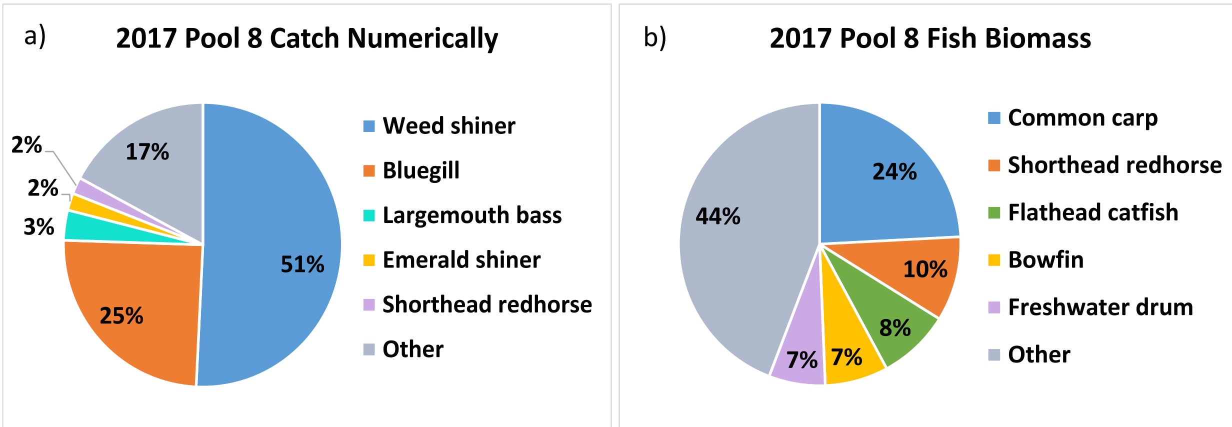

Figure 14. Top species for catch and biomass in samples from Upper Mississippi River Restoration Program – LTRM fish collections in Pool 8 of the Upper Mississippi River during 2017. Data represent samples collected with daytime electrofishing, fyke nets, mini fyke nets, large and small hoop nets, and otter trawls.

Three Wisconsin-listed threatened species, Blue Sucker (1), Black Buffalo (1), and River Redhorse (7), were collected in the Pool 8 LTRM catch this year. One Lake Sturgeon, a species of special concern, was also collected.

We also identified a new species for Pool 8 LTRM records: Largescale Stoneroller. One individual, 79 mm TL was collected in a side channel border electrofishing run on October 19. This new species increased the LTRM fish species total in Pool 8 to 91.

Through 2017, the Pool 8 LTRM sampling efforts have not detected any Asian carp (Bighead, Silver, or Black). This year, we caught 282 Common Carp, which was more typical of recent years, and showed that the 2016 boom was likely a temporary anomaly. The long-term decline of Common Carp, the only current non-native fish species of significance in Pool 8, continues, and is illustrated by mass-per-unit-effort (MPUE) depicted in Figure 15. Day electrofishing CPUE for Common Carp, although not depicted here, was similar to MPUE. Conversely, CPUE for fyke nets (also not depicted) showed a small increase in 2017 over 2016, but not enough to offset a long-term declining trend.

Shannon-Wiener Diversity Index scores for day electrofishing in Pool 8 LTRM samples (Figure 16) declined in 2017, for the third straight year. The second-order polynomial trend line displayed with the data has flattened since 2014, but is still a better fit than simpler equational depictions. Removing the anomalous 2007 and 2011 years likely would result in a flat trend over the past 20 years, which corresponds roughly with the period of aquatic vegetation resurgence in Pool 8. Interestingly, 2007 was a year with relatively low mean annual discharge, and 2011 had one of the highest (Figure 1b); thus, any relationship between fish community diversity and discharge seems inconsistent. Linking fish community attributes to abiotic driving forces illustrates the necessity of monitoring over long time frames, as there are many short-term perturbations that do not necessarily indicate real trends.

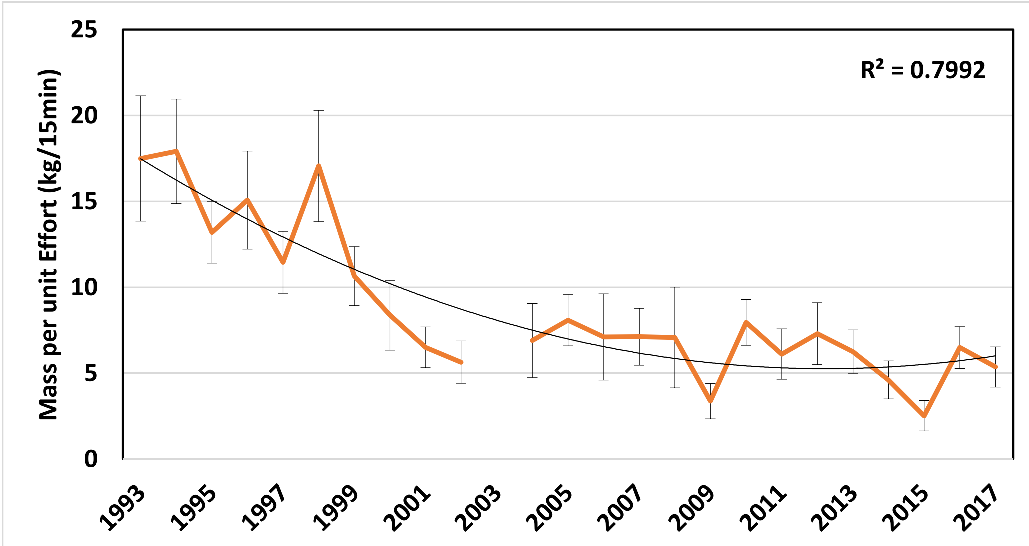

Figure 15. Mass per unit effort (MPUE) of Common Carp in daytime electrofishing samples from Upper Mississippi River Restoration Program – LTRM fish collections in Pool 8 of the Upper Mississippi River, 1993-2017. Data are omitted for 2003 due to limited sampling that year. Trend line is a second-order polynomial representation of the data.

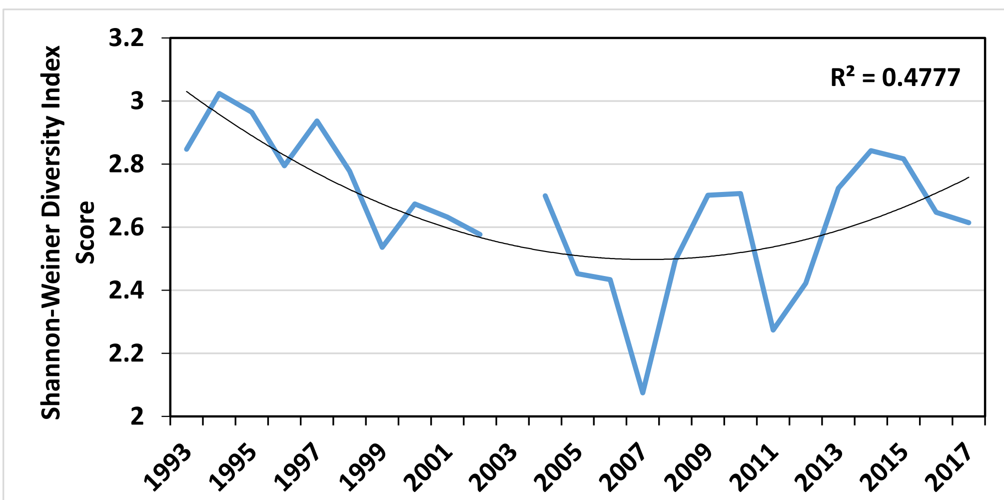

Figure 16. Shannon-Wiener Diversity Index Scores calculated from LTRM Pool 8 day electrofishing samples from 1993-2017. Data are omitted for 2003 due to limited sampling that year. Trend line is a second-order polynomial representation of the data.

Overall, the Pool 8 fish community remains healthy. Catch rates were high in 2017, and, despite the numerical dominance of just a few species, biomass patterns indicate a great deal of balance. Species richness has also rebounded to the highest level in 14 years. Diversity is down from where it was two decades ago, but higher than one decade ago. Rare and protected species are caught each year, and the only invasive species present in detectable numbers is doing poorly.

Species of Interest

Trend data for 10 fish species of interest to anglers are briefly discussed on the following pages. These are cursory examinations, using daytime electrofishing data for consistency and a second gear for comparison. CPUE includes all sizes of fish collected; therefore juvenile fish could potentially have great influence on the catch rates. Further, sample size is very limited for PSD calculations in some instances. Thus, caution is suggested in the interpretation of these results. Further examination of patterns and trends may be possible through data from other LTRM gear types by means of the LTRM graphical fish database browser, referenced in the Methods section above.

Black Crappie

Black Crappie daytime CPUE increased in 2017 for both daytime electrofishing and fyke nets (Figure 17 top and middle). Electrofishing CPUE was still below the long-term mean, but fyke net CPUE rose above the long-term mean.   Overall, the trend seems stable for both gears over the past 20 years, with more variability in the electrofishing catch rates, probably due to smaller sample sizes. The PSD graph for Black Crappie (Figure 17 bottom) indicates perhaps a slight increase over time, but is essentially stable.

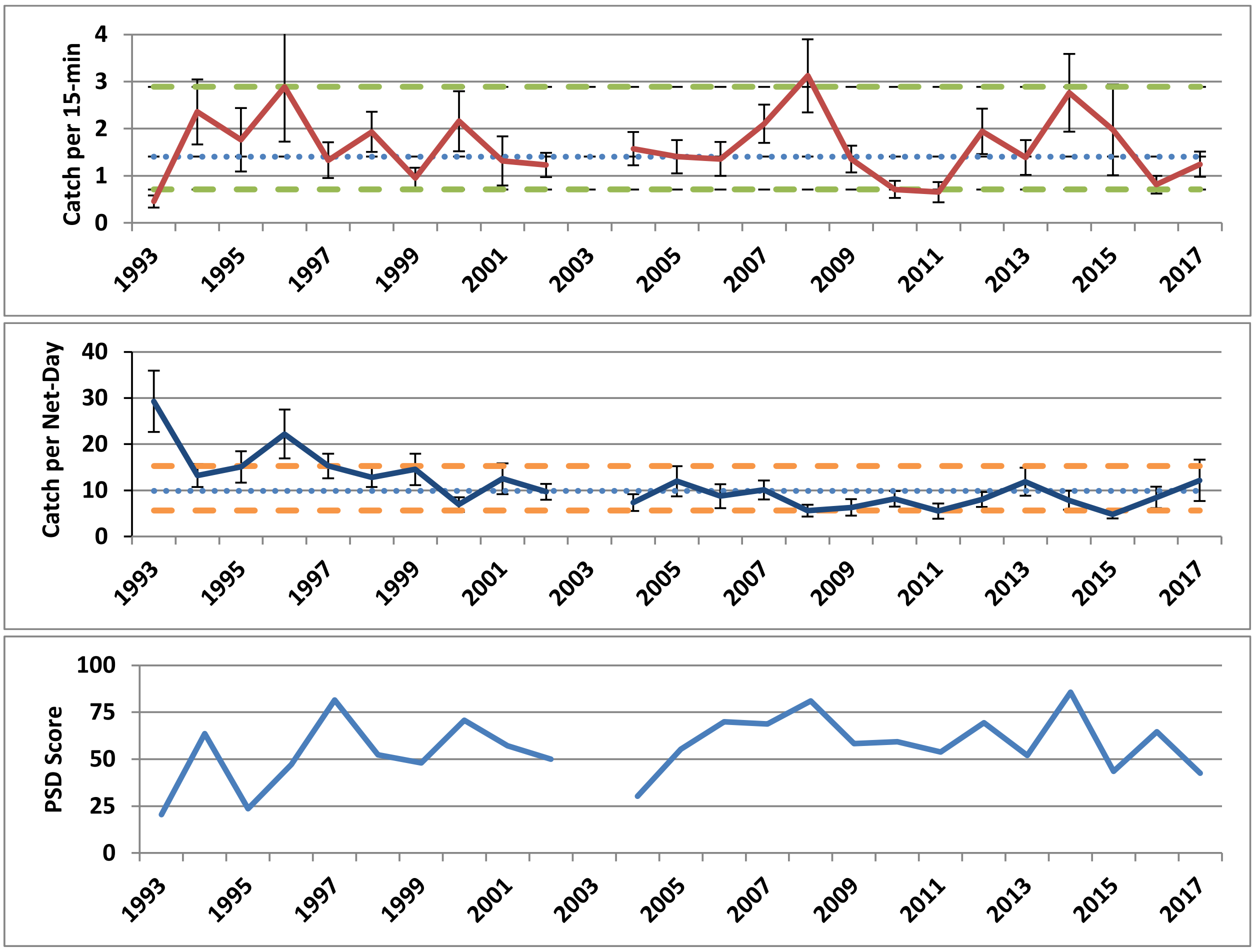

Figure 17. Catch per unit effort (± 1SE) for daytime electrofishing (top graph), catch per unit effort (± 1SE) for fyke netting (middle graph), and proportional stock-density (bottom graph) of Black Crappie collected by day electrofishing in Navigation Pool 8, Upper Mississippi River, by the Upper Mississippi River Restoration Program – LTRM. The long dashed lines on the CPUE graphs represent the 10th and 90th percentiles and the dotted line represents the long-term average for the period of record (1993-2017).

Bluegill

Bluegill daytime electrofishing CPUE in 2017 rebounded from a 4-year decline back to the long-term mean (Figure 18 top). Fyke net CPUE (Figure 13 middle) has shown a similar long-term pattern as electrofishing, but actually declined to slightly below the mean in 2017. PSD values for Bluegill (Figure 18 bottom) have been remarkably consistent and low for most of the LTRM time frame, with all values since 2003 between 14 and 33. The general decline in Bluegill catch rates since the early 2000’s warrants scrutiny, as Bluegill are considered a representative species for backwater habitats. The species is still faring well, though, as it constituted 25% of the numeric catch for the year. Also, of note is that from 2005-2009 we only sampled Periods 2 and 3, which may skew comparisons.

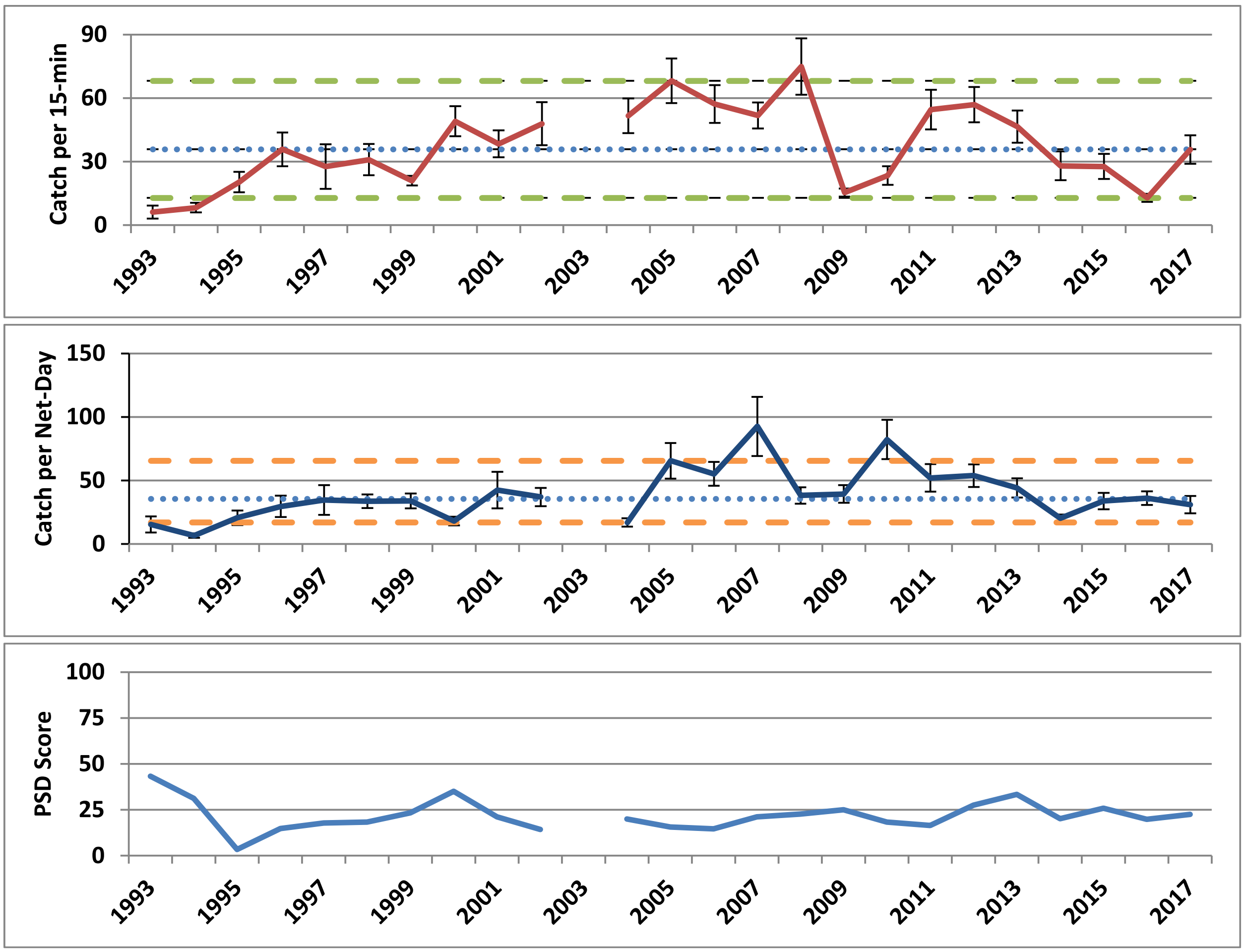

Figure 18. Catch per unit effort (± 1SE) for daytime electrofishing (top graph), catch per unit effort (± 1SE) for fyke netting (middle graph), and proportional stock-density (bottom graph) of Bluegill collected by day electrofishing in Navigation Pool 8, Upper Mississippi River, by the Upper Mississippi River Restoration Program – LTRM. The long dashed lines on the CPUE graphs represent the 10th and 90th percentiles and the dotted line represents the long-term average for the period of record (1993-2017).

Channel Catfish

Channel Catfish CPUE for daytime electrofishing declined in 2017, and was below the long-term average in Pool 8 for the third time in four years (Figure 19 top). Catch rates for Channel Catfish with day electrofishing have been generally low, but stable, over time. Wide error bars also indicate variability among sites within given years, as many sites sampled with daytime electrofishing do not provide good habitat for Channel Catfish (I.e., low flow rates). CPUE for small hoop netting (Figure 19 middle) shows a decline from the earliest years of the program, and in 2017 it declined to the 10th percentile for the period of record. PSD values (Figure 19 bottom) from daytime electrofishing for Channel Catfish have remained consistently high over time. These observations would suggest a very stable size structure, with a high percentage of quality-sized fish and low recruitment, for Channel Catfish in Pool 8.

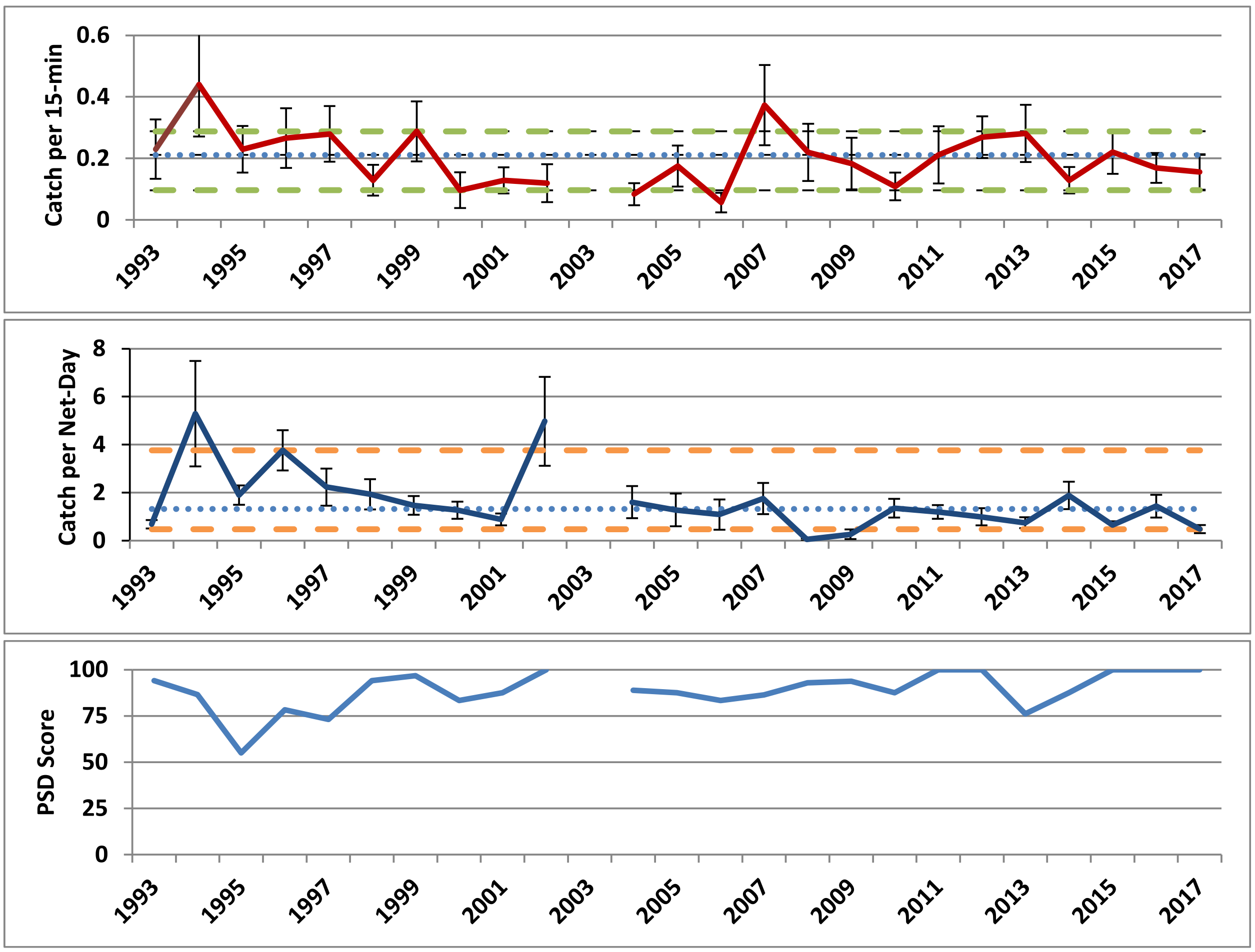

Figure 19. Catch per unit effort (± 1SE) for daytime electrofishing (top graph), catch per unit effort (± 1SE) for small hoop netting (middle graph), and proportional stock-density (bottom graph) of Channel Catfish collected by day electrofishing in Navigation Pool 8, Upper Mississippi River, by the Upper Mississippi River Restoration Program – LTRM. The long dashed lines on the CPUE graphs represent the 10th and 90th percentiles and the dotted line represents the long-term average for the period of record (1993-2017).

Flathead Catfish

Daytime electrofishing CPUE for Flathead Catfish rebounded in 2017 from near the 10th percentile to an all-time LTRM-era high (Figure 20 top). CPUE from large hoop nets (Figure 20 middle) reinforces the electrofishing data, with an amazing 2017 CPUE that was almost double any previous value. PSD score increased in 2017 to more typical recent levels (Figure 20 bottom), indicating a number of quality-sized fish in the population. Catches of this large-bodied species have always been quite variable, but the 2017 numbers suggest that, at least for the present, Flathead Catfish are major players in the Pool 8 predatory fish group.

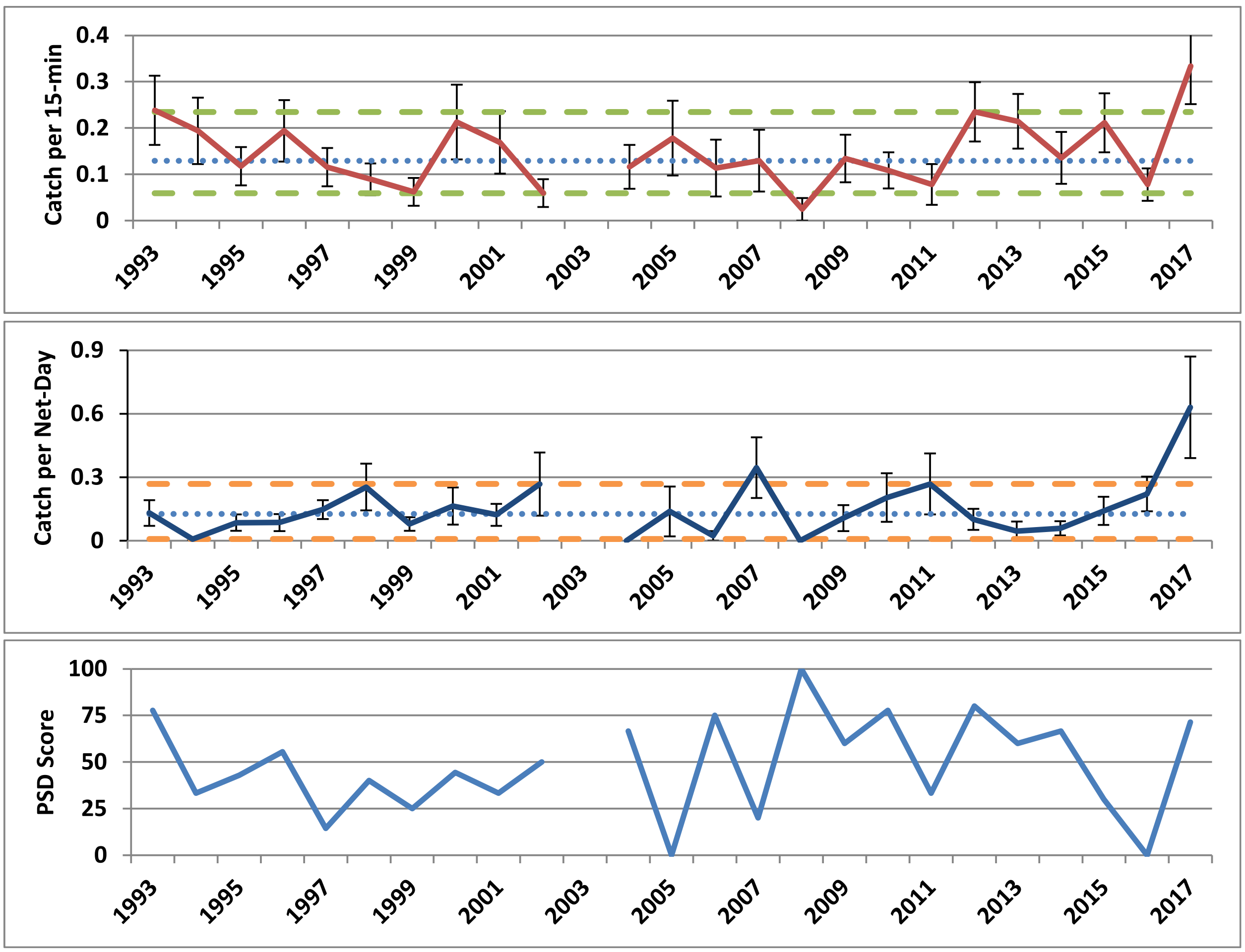

Figure 20. Catch per unit effort (± 1SE) for daytime electrofishing (top graph), catch per unit effort (± 1SE) large hoop netting (middle graph), and proportional stock-density (bottom graph) of Flathead Catfish collected by day electrofishing in Navigation Pool 8, Upper Mississippi River, by the Upper Mississippi River Restoration Program – LTRM. The long dashed lines on the CPUE graphs represent the 10th and 90th percentiles and the dotted line represents the long-term average for the period of record (1993-2017).

Largemouth Bass

Largemouth Bass CPUE for daytime electrofishing declined slightly in 2017 from 2016, but was still above the long-term mean (Figure 21 top). Fyke netting CPUE (Figure 21 middle) shows some Largemouth Bass in the catch from 2005 through 2012, a period when electrofishing CPUE was also high. Though CPUE values have fallen from their peak in 2005-2009 (the time when Period 1 sampling was eliminated), they have been on a slow and steady long-term increase**.** Daytime electrofishing CPUE over the last decade was still more than double catch rates in the 1990's. Stable, to slightly increasing PSD trend over time (Figure 21 bottom) indicates good or improving size structure over time, as well as at least periodic recruitment events.

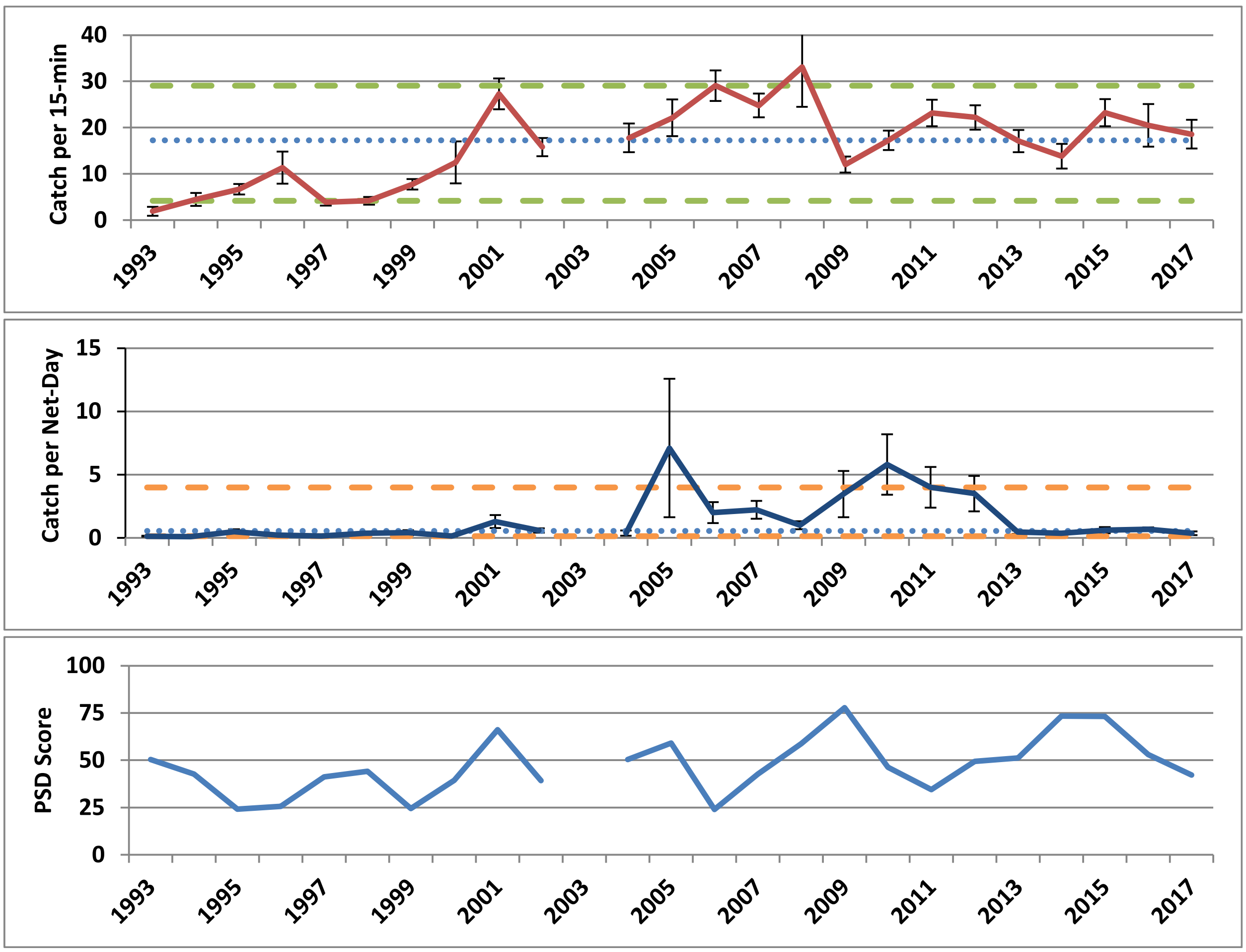

Figure 21. Catch per unit effort (± 1SE) for daytime electrofishing (top graph), catch per unit effort (± 1SE) fyke netting (middle graph), and proportional stock-density (bottom graph) of Largemouth Bass collected by day electrofishing in Navigation Pool 8, Upper Mississippi River, by the Upper Mississippi River Restoration Program – LTRM. The long dashed lines on the CPUE graphs represent the 10th and 90th percentiles and the dotted line represents the long-term average for the period of record (1993-2017).

Northern Pike

Northern Pike daytime electrofishing CPUE rebounded to the LTRM Pool 8 mean in 2017 (Figure 22 top). Fyke netting CPUE (Figure 22 middle) decreased slightly in 2017, but was still above the long-term mean. Despite some recent fluctuations, CPUE values for both gears are generally higher than values from the 1990's, and seem to indicate healthy a population. The PSD value (Figure 22 bottom) for Northern Pike remained low in 2017, and suggests sustained recruitment of young fish. Lower PSD values in recent years (7 of the last 8 years below PSD of 50) indicate a younger fishery, rather than one dominated by larger individuals.

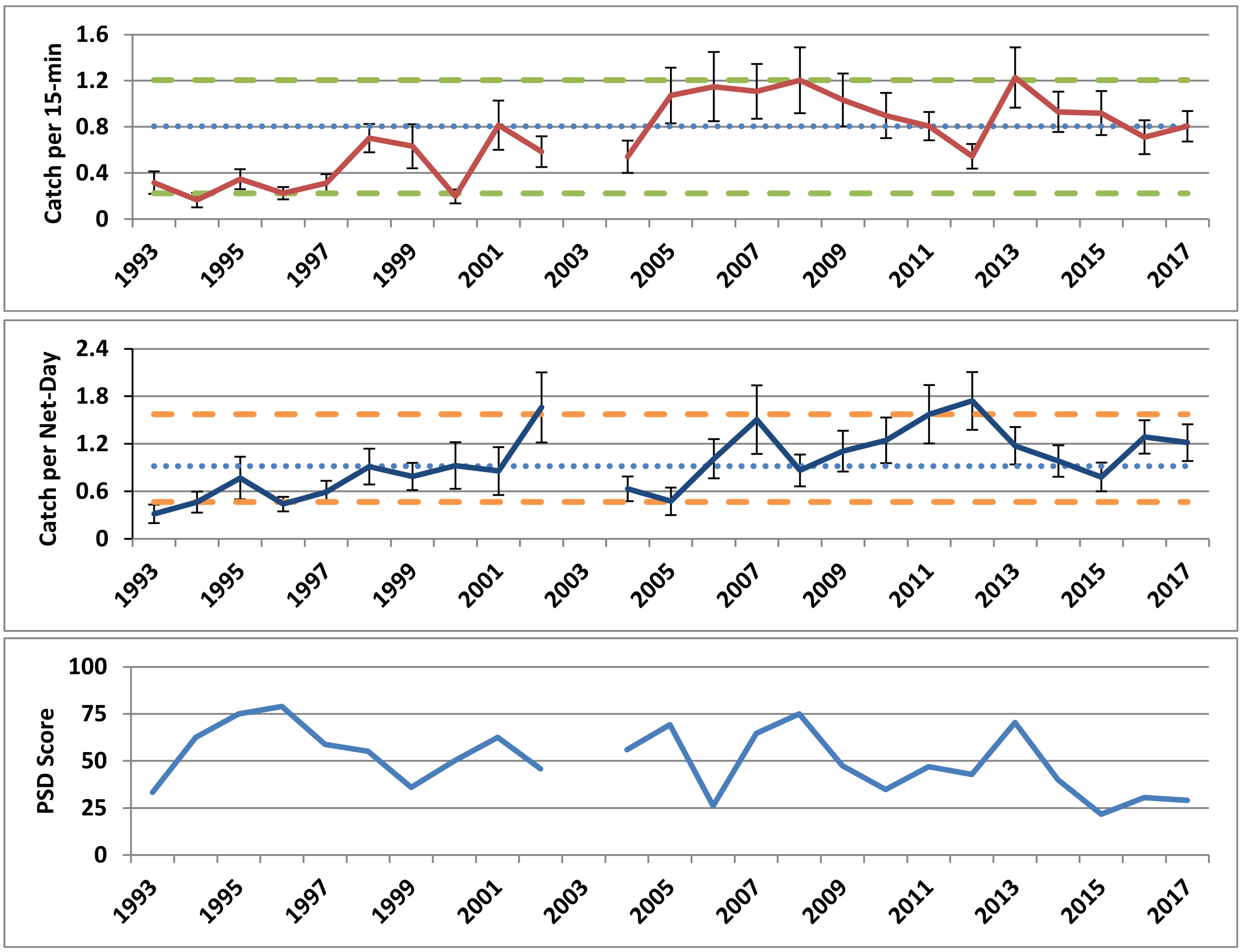

Figure 22. Catch per unit effort (± 1SE) for daytime electrofishing (top graph), catch per unit effort (± 1SE) fyke netting (middle graph), and proportional stock-density (bottom graph) of Northern Pike collected by day electrofishing in Navigation Pool 8, Upper Mississippi River, by the Upper Mississippi River Restoration Program – LTRM. The long dashed lines on the CPUE graphs represent the 10th and 90th percentiles and the dotted line represents the long-term average for the period of record (1993-2017).

Sauger

Sauger CPUE for daytime electrofishing has, for many years, been below that of the 1990's (Figure 23 top), and has remained below the historic LTRM mean for 10 years. Fyke netting CPUE (Figure 23 middle) paints a similar dismal picture, as the long-term mean and tenth percentile are both approaching zero. However, a viable population remains, as the species persists. Sauger PSD (Figure 23 bottom) has indicated an increasing trend over time, and was 80 in 2017. This PSD trend suggests a trend toward reduced recruitment. While the current LTRM gear/stratum combinations do not achieve high catch rates or large sample sizes, they do likely reflect a reduced Sauger population. Consistently low catch rates for more than a decade suggest the need for some type of management action.

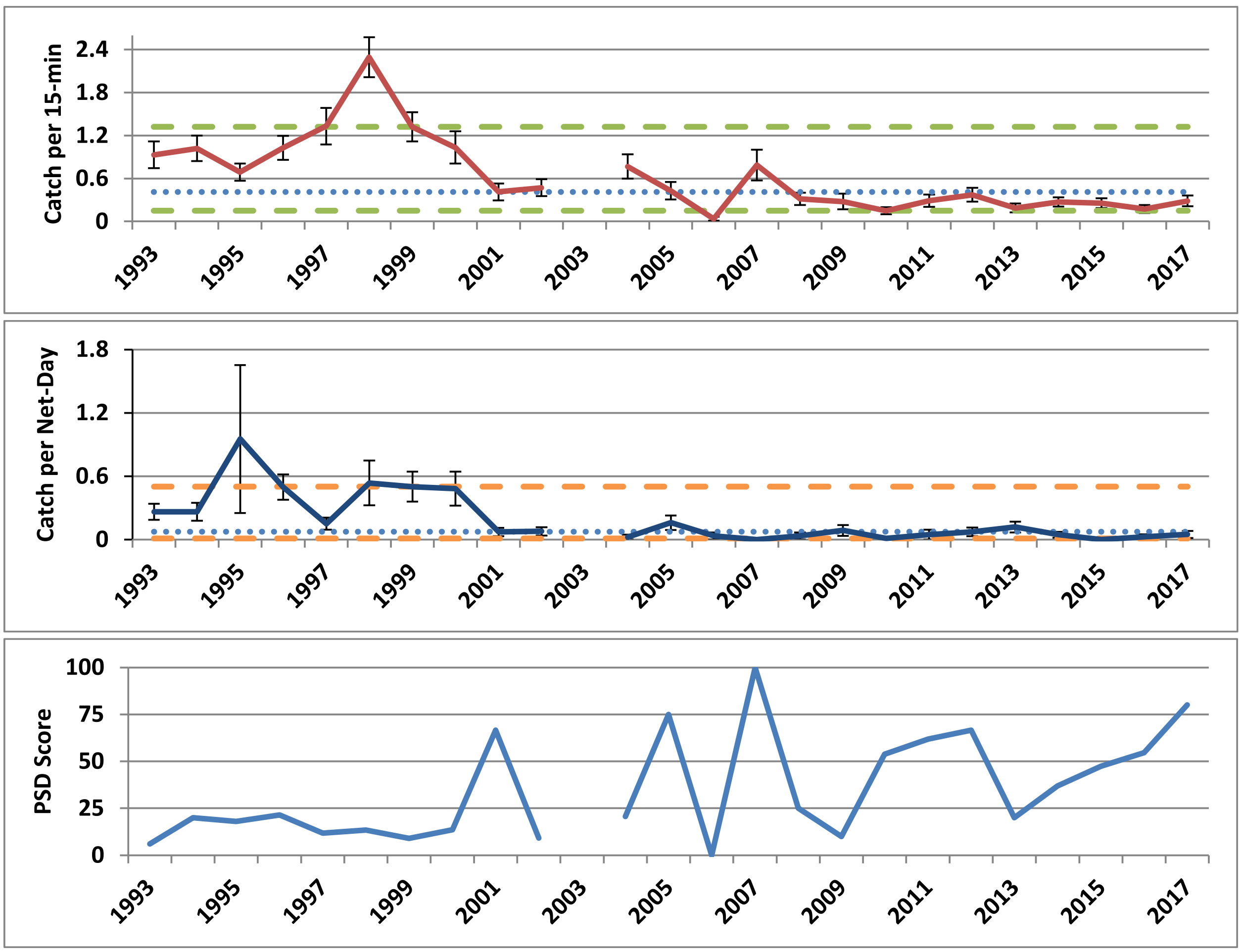

Figure 23. Catch per unit effort (± 1SE) for daytime electrofishing (top graph), catch per unit effort (± 1SE) fyke netting (middle graph), and proportional stock-density (bottom graph) of Sauger collected by day electrofishing in Navigation Pool 8, Upper Mississippi River, by the Upper Mississippi River Restoration Program – LTRM. The long dashed lines on the CPUE graphs represent the 10th and 90th percentiles and the dotted line represents the long-term average for the period of record (1993-2017).

Smallmouth Bass

Smallmouth Bass daytime electrofishing CPUE has been on the increase since a low point in 2009 (Figure 24 top), except for a setback in 2013. CPUE rose above the long-term mean in 2017, for the first time in a decade, and was the highest since the late 1990's. Large hoop netting was the only other gear type that collected many Smallmouth Bass. Although not a very efficient sampling gear for Smallmouth Bass, large hoop netting CPUE (Figure 24 middle) shows an increase in catch rate since 2010. The PSD graph (Figure 24 bottom) suggests a stable size structure, perhaps with an increasing trend, and between 50% and 75% of the catch achieving quality size.

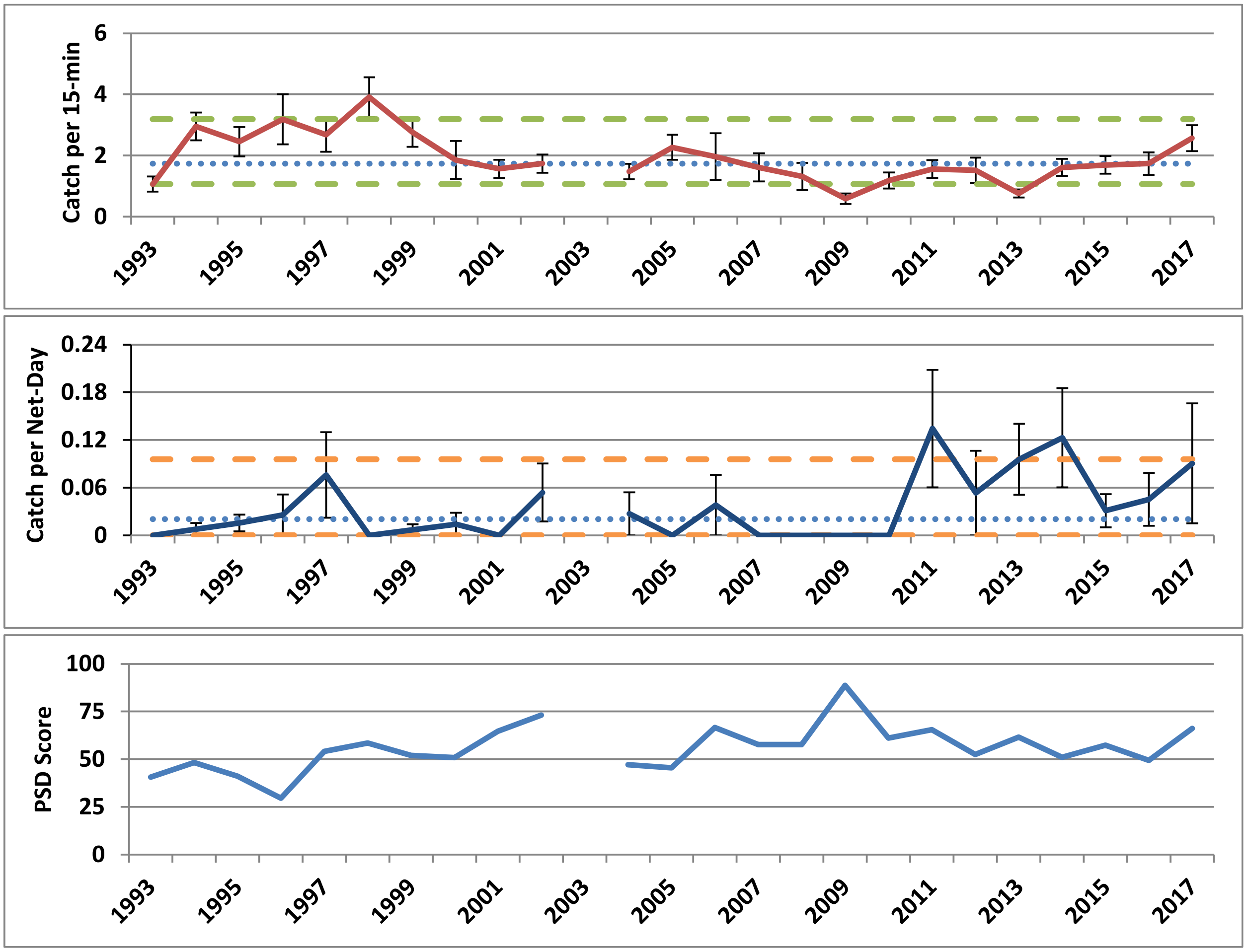

Figure 24. Catch per unit effort (± 1SE) for daytime electrofishing (top graph), catch per unit effort (± 1SE) large hoop netting (middle graph), and proportional stock-density (bottom graph) of Smallmouth Bass collected by day electrofishing in Navigation Pool 8, Upper Mississippi River, by the Upper Mississippi River Restoration Program – LTRM. The long dashed lines on the CPUE graphs represent the 10th and 90th percentiles and the dotted line represents the long-term average for the period of record (1993-2017).

Walleye

Walleye daytime electrofishing CPUE increased slightly in 2017 (Figure 25 top), exceeding the long-term mean for the second time in three years, and continuing a slight increasing trend since 2010. The fyke net CPUE graph (Figure 25 middle) exhibits more variability than electrofishing, although the 2017 CPUE was among the lowest in the LTRM era. Walleye PSD values (Figure 25 bottom) depict a stable, perhaps decreasing trend over time, with scores usually ranging from about 40 to 80. Sample size with these two gear types is limited; thus, caution is advised in drawing interpretations of these data.

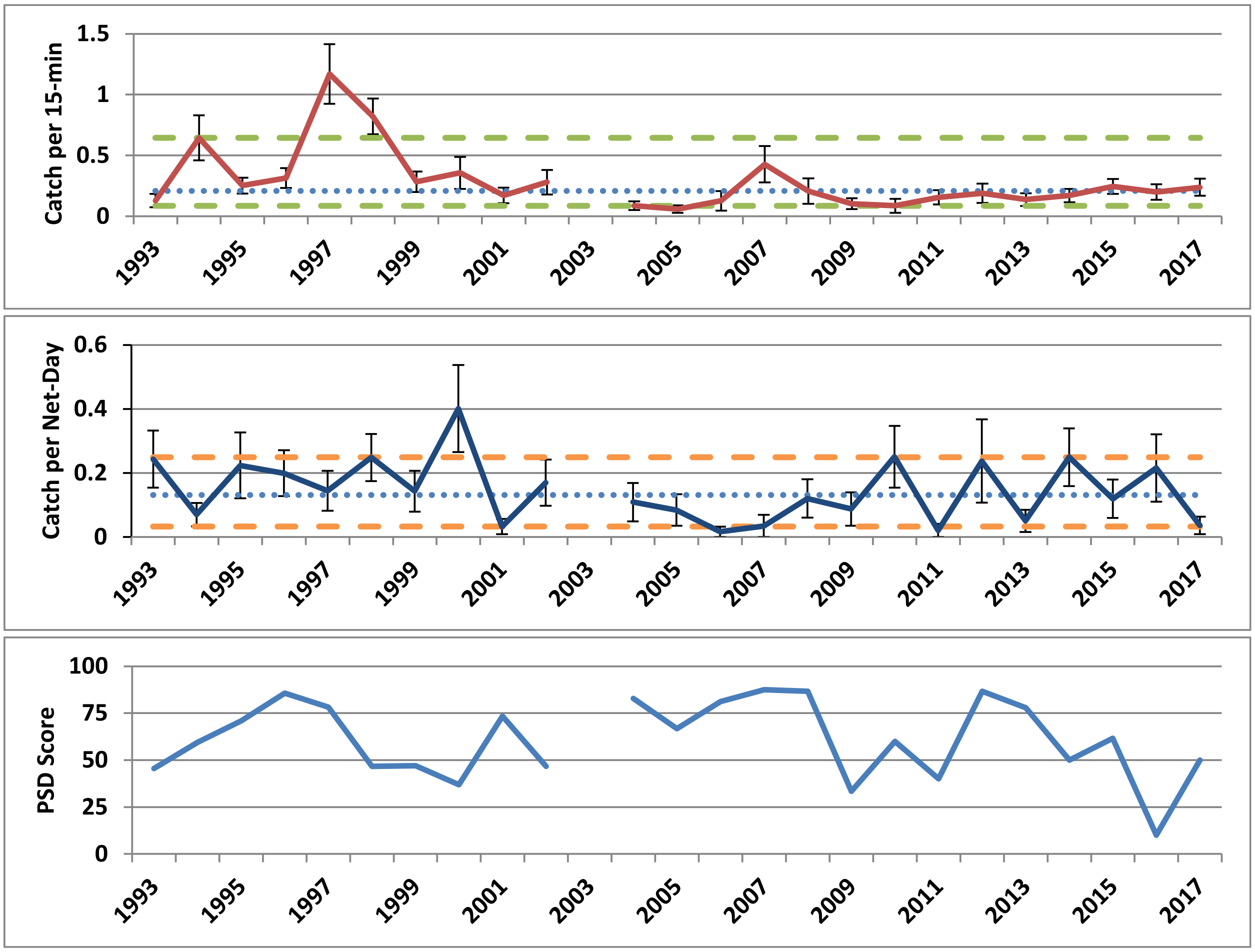

Figure 25. Catch per unit effort (± 1SE) for daytime electrofishing (top graph), catch per unit effort (± 1SE) fyke netting (middle graph), and proportional stock-density (bottom graph) of Walleye collected by day electrofishing in Navigation Pool 8, Upper Mississippi River, by the Upper Mississippi River Restoration Program – LTRM. The long dashed lines on the CPUE graphs represent the 10th and 90th percentiles and the dotted line represents the long-term average for the period of record (1993-2017).

Yellow Perch

Daytime electrofishing CPUE rebounded in 2017 (Figure 26 top), which was the fourth time in nine years that perch CPUE approached or exceeded the 90th percentile. Fyke net CPUE for Yellow Perch (Figure 26 middle) remained slightly above the long-term mean, where it has been for the past five years. The PSD graph (Figure 26 bottom) has shown some fluctuations, but generally still indicates a general pattern of increase through time. Less than 50% of adult fish captured have been of quality size in most years, suggesting high recruitment, high adult mortality, or both.

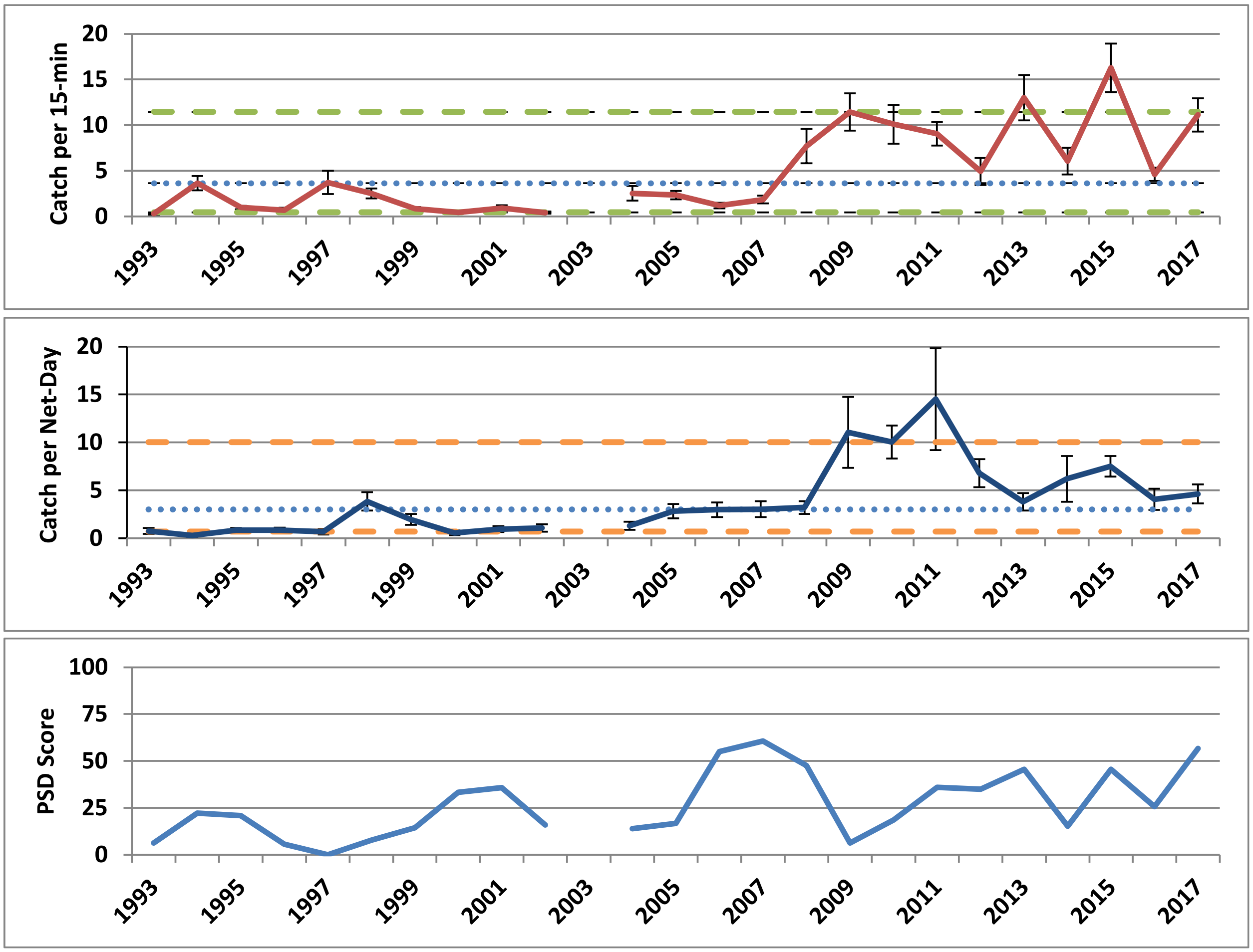

Figure 26. Catch per unit effort (± 1SE) for daytime electrofishing (top graph), catch per unit effort (± 1SE) fyke netting (middle graph), and proportional stock-density (bottom graph) of Yellow Perch collected by day electrofishing in Navigation Pool 8, Upper Mississippi River, by the Upper Mississippi River Restoration Program – LTRM. The long dashed lines on the CPUE graphs represent the 10th and 90th percentiles and the dotted line represents the long-term average for the period of record (1993-2017).

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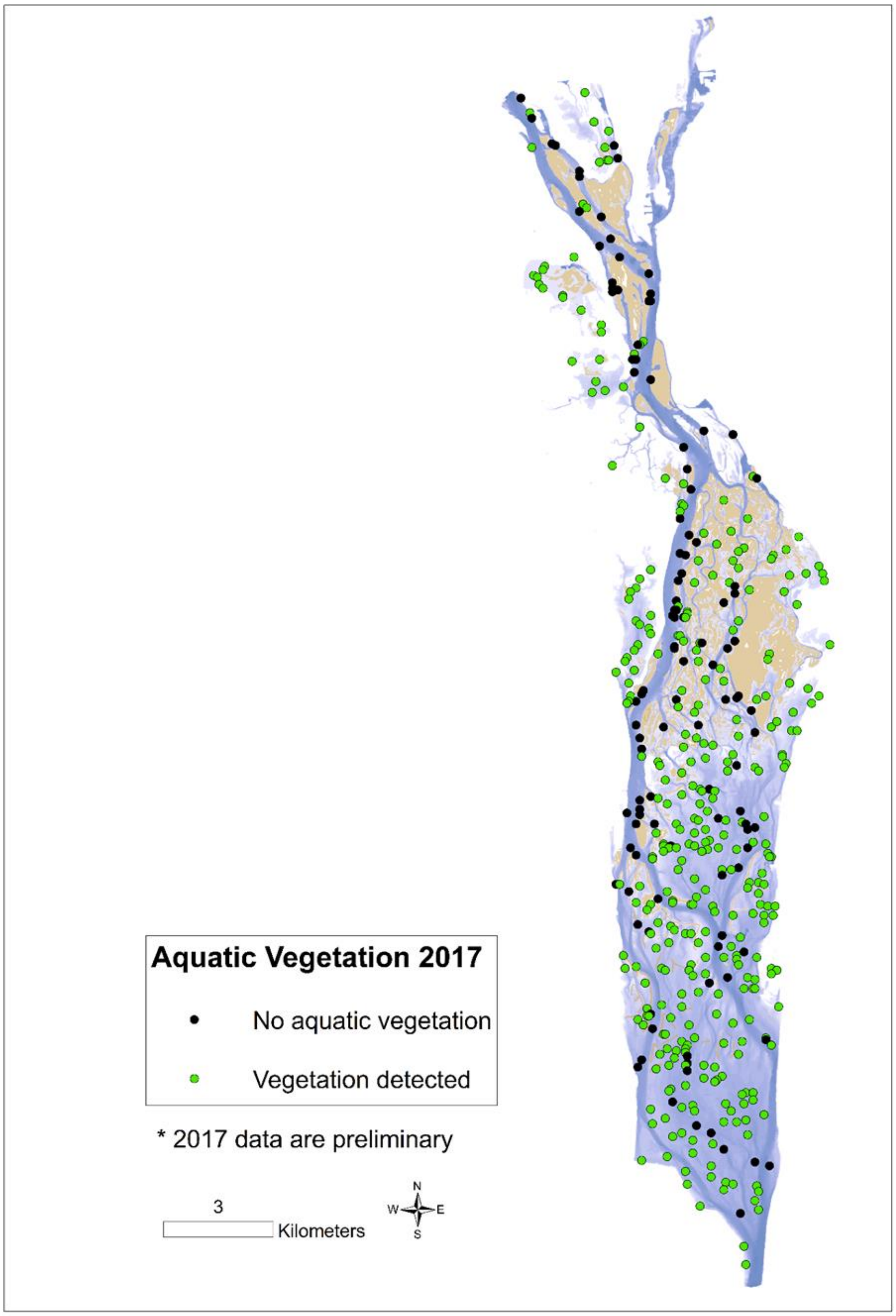
Appendix



Appendix A. Locations of the 450 sites visited in 2017 aquatic vegetation surveys – vegetated sites (339) are marked in green and unvegetated sites (111) are in black. Most of the unvegetated sites were located in the main channel and side channels with high water velocity and depth.