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The Nature Conservancy's Emiquon Preserve

Fish and Aquatic Vegetation Monitoring

2023 Field Report

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Floodplain restoration monitoring of the aquatic vegetation and fish communities of The Nature Conservancy's Emiquon Preserve 2023

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Disclaimer

Under contract with The Nature Conservancy (TNC), fish and aquatic vegetation monitoring (2007-present) was conducted on Thompson and Flag lakes of the Emiquon Preserve by the Illinois Natural History Survey's (INHS) Illinois River Biological Station (IRBS) to evaluate a series of key ecological attributes (KEA) relevant to restoration success. This report presents a summary of data collected during the 2023 field season with trends from previous years. The findings, conclusions, and views expressed herein are those of the researchers and should not be considered as the official position of TNC or the INHS.

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Executive Summary

Overall conclusions:

Since 2007, the Emiquon Preserve (Emiquon) has been monitored using Key Ecological Attributes (KEA) to determine the success of restoration on the vegetation and fish communities. The KEA's were developed to reflect a high-functioning, balanced ecosystem at its upper limits.

Submersed aquatic vegetation (SAV) abundance and richness have been estimated using both a rake sampler method of the United States Geological Survey's (USGS) Upper Mississippi River Restoration (UMRR) program's Long Term Resource Monitoring (LTRM) program, and also a box sampler method for precise biomass estimation. These both involve repeatable long-term sampling and have been employed at the Emiquon Preserve from 2008-2015 (rake), and 2016-2022 (box), and both were employed in independent surveys in 2023. Even with re-institution of the LTRM rake method in 2023, the box sampler method was continued so that our dataset can include overlapping years for the two methods. 2023 is the first of at least 3 planned years which will have both methods employed at the preserve. SAV communities have continued to be dominated by native species from 2008 through 2023. SAV densities in 2023 were similar to those since 2021, which are about 20% of values during 2016-2020 and about 10% of values during 2010-2015. Water transparency has remained low enough (less than 20 cm mean Secchi readings) since 2020 that the KEA for Secchi depth has not been met. The community has shifted from more sensitive species to those that are more robust in the face of more turbid water conditions. Specifically, the community has shifted from coontail (*Ceratophyllum demersum*), Canadian waterweed (*Eulodea canadensis*), and naiads (*Najas spp.*) to milfoils (*Myriophyllum spp.*) and American lotus (*Nelumbo lutea*) with patches of naiads, coontail, or longleaf pondweed (*Potamogeton nodosus*).

The Emiquon Preserve's fish community continues to be dominated by native fish species. In 2023, the community was dominated by bluegill (*Lepomis macrochirus*), gizzard shad (*Dorosoma cepedianum*), and yellow bass (*Morone mississippiensis*) by numbers (Fig. 14). While mosquitofish (*Gambusia affinis*) were a large portion of the numerical catch for 2023 (1,906 individuals), this was largely due to a single mini fyke net that captured a spawn of mosquitofish in the northeast section of Thompson in September (1,833 fish). By biomass, the 2023 fish community sampled by our monitoring gears was primarily bowfin (*Amia ocellicauda*)

and yellow bass, with common carp (*Cyprinus carpio*), black crappie (*Pomoxis nigromaculatus*), gizzard shad, channel catfish (*Ictalurus punctatus*), largemouth bass (*Micropterus nigricans*), white crappie (*Pomoxis annularis*), and white bass (*Morone americana*) contributing noticeable biomass as well. It is worth noting that yellow bass collections went from 0 in 2015 and 2 in 2017 to 3,310 in 2021 and 1,406 in 2023 (Fig. 23). As a small piscivore, this rapid population increase may impact other piscivore populations at Emiquon. The populations of several native species are abundant at Emiquon; however, it is worth noting that largemouth bass CPUE in Emiquon in 2023 was the lowest on record and was for the first time not significantly greater than LTRM-sampled largemouth bass CPUE in backwaters of the LaGrange pool of the Illinois River. Overwinter under-ice oxygen levels, when measured, have been good (i.e., between 7 and 10 ppm and between 75% and 110% saturation).

Detailed conclusions:

Vegetation Indicators:

Key Ecological Attributes for SAV assess underwater irradiance, hydrology, and community composition; but only hydrology and community composition were measured for emergent/floating leaved vegetation.

- Annual mean secchi disc transparency was high (over 60 cm) at the beginning of the restoration, remained mostly between 30 and 60 cm from 2010 through 2020, and has been a consistent 20 cm since 2020 (was also 19 cm in 2018). With the exception of 2012 (a drought year) and 2018 (the first drawdown year), Secchi depths met the goal (KEA1) of being at least half the depth for at least 50% of the sampling events throughout the year all the way through 2019. However, since 2020, this goal has not been met.
- Since 2008, water levels have only risen more than 1.5 cm/day on fewer than 25% of days in any given year. During the peak SAV growing season that timeframe, water level rise has never exceeded a total of 1 m per month (KEA 2) in any year since 2008.
- SAV densities are low compared to historic densities. Values in 2023 and 2021 were about 20% of values during 2016-2020 and about 10% of values in 2010-2015. Community composition of SAV met the desired range of <10% non-native species in 2023 based on LTRM rake scores (4% non-native), but the KEA was not met when considering box sampler biomass estimates (12% non-native) (KEA 3). Much of the milfoil collected in 2023 rake

surveys contained less than 12 leaflets on one side of the leaf, indicating these were native northern milfoil (*Myriophyllum sibiricum*) or at least potential hybrids with the invasive Eurasian milfoil (*M. spicatum*). If these detections in 2023 were true northern milfoil, it is possible that previous years reported some native milfoil plants as the invasive milfoil due to looking for different distinguishing characters.

Fish Indicators:

Key Ecological Attributes established for fish populations assess the fish community assemblage and composition and spawning, nursery, feeding, and overwintering success at Emiquon.

- During 2023 sampling efforts, 28 common carp were collected across all gear types and removed from the population.
- Yellow bass populations rebounded in 2023 from 2022 low back to high levels seen in recent years, and therefore seem to be remaining high and perhaps increasing. During 2023 routine sampling, 1,406 adult and young of year yellow bass were caught.
- In 2023, a total of 25 native species and 1 non-native species (common carp) were captured during routine sampling. A total of 40 species (37 native and 3 non-native) have been collected cumulatively since 2007 during routine sampling (KEA 6).
- An additional three species, paddlefish (*Polydor spathula*), grass carp (*Ctenopharyngodon idella*), and bighead carp (*Hypophthalmichthys nobilis*), have all been captured during non-routine gill netting in previous years, bringing the total species count across all years to 43 (40 native and 3 non-native) (KEA 6).
- Native fish biomass comprised 89.6% of the total biomass of fish in Emiquon, 90.6% of the biomass collected at random sites, and 87.2% of the biomass at fixed sites in 2023. Non-native species composition remains < 2% by number and < 25% by biomass (KEA 7).
- Native predatory fish populations (catch-per-unit-effort (CPUE)) of largemouth bass was 9.0 fish/hr in 2023. Catch per unit effort of largemouth bass has been consistently below the desired KEA range of at least 50 fish/hr since 2021. In 2023, CPUE of largemouth bass was not statistically greater in Emiquon than in the La Grange pool of the Illinois River for the first time since restoration of Thompson Lake. Bowfin and gar species (i.e., spotted gar (*Lepisosteus oculatus*), shortnose gar (*L. platostomus*) and longnose gar

(*L. osseus*)) have been present in all years. Alligator gar (*Atractosteus spatula*) were released in 2020 by the Nature Conservancy and the Illinois Department of Natural Resources. During 2020 sampling, two alligator gar were captured at 388mm, 191g, and 426mm, 264g. (KEA 8).

- Dissolved oxygen yearly averages have consistently been above the minimum levels required by fish during spawning (>5 ppm) in all years (KEA 1).
- Although large woody debris is minimal, shading is often provided by abundant submersed and emergent aquatic vegetation present at Emiquon. Enhancements could be made to produce a more diverse shoreline such as shade, fallen trees, open areas, and submerged plants (KEA 10).
- Water levels at Emiquon remained higher than drawdown years, but were still lower than levels in pre-drawdown years. Late summer water levels were lower and dried up some higher elevation vegetation beds (e.g. in Swan Bay) where abundant native vegetation was present.
- A free-flowing connection at Emiquon is rare and fish access is often obstructed by stop logs. When a connection is established, access to the Preserve by riverine fish for spawning and nursery purposes in often restricted by screens for larger fish and by flow rates for YOY fish (KEA 11 and KEA 12).
- Of the three desired young-of-year (YOY) species, freshwater drum (*Aplodinotus grunniens*), goldeye (*Hiodon alosoides*), and bigmouth buffalo (*Ictiobus cyprinellus*), only freshwater drum and bigmouth buffalo have been collected (KEA 12).
- Although not collected during standardized sampling methods, adult paddlefish have been collected using trammel nets and gill nets during non-standardized sampling efforts in 2018 and 2019 and noted in commercial fishing bycatch (returned alive to the lake) in (2020 and 2022) (KEA 12).
- Largemouth bass, Black Crappie, Bluegill, and Pumpkinseed (*Lepomis gibbosus*) mean relative weights (body condition) decreased from 2022 levels (KEA 14), but all four species continue to show relative weights.
- Aquatic vegetation in littoral areas has consistently remained above the desired range of 25-40% at fish sampling sites, although it is usually sparse and confined to very shallow, very nearshore fringes of the lake at fish sampling sites.

Introduction

Historically, the backwaters of the Emiquon Preserve (Emiquon), Thompson and Flag Lakes, were among the most productive backwater lakes in the Illinois River Valley (IRV). They were disconnected from the Illinois River and reduced to agricultural drainage ditches by 1924. They remained in continuous agricultural production until 2006, becoming one of the largest farms in Illinois. The Nature Conservancy (TNC) initially purchased the Wilder property in 2000, but this area was still farmed until 2006 before aquatic restoration began the following year. As part of the restoration, the surrounding levees were left in place, but the drainage of accumulating water was discontinued, and the drainage ditches were treated with rotenone to eliminate any non-native common carp. Following restoration, Emiquon naturally filled through precipitation and >30 native fish species were stocked by Illinois Department of Natural Resources (IDNR) based on historical fish records of both lakes (Havera et al. 2003, VanMiddlesworth et al. 2016). The staff of the Illinois Natural History Survey's Illinois River Biological Station have been monitoring the submerged aquatic vegetation (SAV) and fish assemblages from 2007 to present. The data collected is used to evaluate Key Ecological Attributes (KEAs) of restoration success. The 19 KEA's assessed in this report were developed in 2004 and revised in 2006 by the Emiquon Science Advisory Council (i.e., TNC and partners) to serve as a management tool for the Emiquon restoration. The knowledge gained may aid in future management efforts at Emiquon and other floodplain restoration efforts.

Methods

Submersed Aquatic Vegetation

Aquatic vegetation samples were collected during August and September, at the peak of the growing season, using two different methods. Forbes Biological Station box-sampler methods (previously employed at Emiquon in 2016-2022) were used at 30 random sites throughout the entire lake system over a 2-month sampling period. Rake sampler methods from the U.S. Army Corps of Engineers' Upper Mississippi River Restoration (UMRR) program's Long-Term Resource Monitoring (LTRM) program (previously employed at Emiquon in 2007-2015) were used at 60 random sites over a 1-month sampling period in August and again at 30

random sites over a 1-month sampling period in September. At every site, the area within 2 m of the boat was visually assessed and scored for aquatic vegetation cover according to LTRM rake sampling scores (for LTRM rake sampler sites), or to the closest 5% mark (for box sampler sites). Water quality parameters including water depth, substrate type, detritus presence, Secchi depth, temperature, dissolved oxygen content and percent saturation, and conductivity were recorded, and in most cases a water sample was taken for later turbidity measurement in the lab. For box sampler sites, we used a random number generator to assign where the box should be placed relative to the boat and a sub-sample was collected within the area using a box sampler that measures 25 cm wide x 45.5 cm long for an area of 0.1183 m^2 sampled. Samples were collected, placed in Ziploc-style bags, returned to the laboratory, and frozen. In the laboratory, the micro- and macroinvertebrates and seeds were rinsed off, each vegetation sample was then sorted and identified to species. Each species within a sample was placed in a weigh boat and weighed to obtain a wet weight. The weigh boat was then placed in a drying oven for 16-48 hours at ≥ 60 °C and weighed again to obtain dry weight. For LTRM rake sampler sites, vegetation sampling was in accordance with Yin et al. (2000) LTRM methods, with 6 transects arranged around the boat. For each transect, the visual occurrence of aquatic vegetation taxa was noted prior to each rake transect pull. Then, a rake transect beginning 1 m away from the boat and pulled toward the boat was conducted, the rake rotated 180°, and pulled up and out of the water. After removing and noting the presence of any emergent or floating vegetation (including any bumped by the rake even if not retrieved), the amount of total submerged aquatic vegetation on the rake was noted according to the notches as per Yin et al. (2000). Then, the SAV was separated into taxonomic groups (mostly to species), and scores were given to each taxon according to relative proportions on the rake and not exceeding the total rake score in sum.

Fish Monitoring

Monthly fish sampling was conducted from April to October annually using a multiple gear approach at random and fixed sites. Sampling gear types included pulsed-DC electrofishing (15 minutes of effort per site, ~200 m), fyke netting (~24 hours each), and mini-fyke netting (~24 hours each) at shoreline or pseudo-shoreline (used for shoreline gear) sites. Fixed sites are located on east side of Thompson Lake for the fyke and mini-fyke nets with the electrofishing site located in the pumphouse ditch between Thompson and Flag Lake. Other sampling sites

were selected randomly within Thompson Lake and all gears were fished according to the UMRR LTRM fish monitoring protocols found in Ratcliff et al. (2014).

Sampling Effort (2007-2023)

Submersed Aquatic Vegetation

2023 was the first of three years in which both the box sampler (previously employed 2016-2022) and the LTRM rake sampling method (previously employed 2007-2015) are planned to be employed in the same year at the Emiquon Preserve. The box sampler method was used at 30 random sites throughout the entire lake system over a 2-month sampling period. LTRM rake sampler methods were used at 60 random sites over a 1-month sampling period in August and again at 30 random sites over a 1-month sampling period in September. For all three sampling period snapshots, random sites were separated by 150 m (Sep rake) or 200 m (August rake and Sep-Aug box). For all three sampling snapshots, there were also randomly-generated alternates equal in number to the primary sites (with the exception of the August rake sampler because only 118 were able to fit within the in-lake polygon at 200m separation). Forbes box sampler sites were distributed randomly throughout the lake polygon. LTRM rake sampler sites were distributed throughout Thompson and Flag lakes aquatic vegetation communities after stratifying the preserve into three regions: North, Middle, and South based on LTRM rake sampling designs used at Emiquon during 2010-2015. If the site was entirely unvegetated (verified by at least one rake pull when at an open water mid-lake site), then the closest alternate not in open water in the mid-lake region was added in an attempt to detect what vegetation is present in low-vegetation years. In 2023, we visited all alternate sites that were not in open water of the mid-lake. The final count of sites visited includes 85 (44 open water unvegetated) rake sampler sites in August, 42 (15 open water unvegetated) rake sampler sites in September, and 40 (29 open water unvegetated) box sampler sites in August and September combined, for a total of 167 vegetation sites of which 88 were unvegetated open water. We obtained turbidity samples at 113 of those sites.

Vegetation samples from 2016-2023 were collected using the box sampler method during July or August to obtain an accurate measurement of biomass. A visual estimation was made in a

1-m perimeter around the boat, and then a subsample was collected using a box sampler. The subsample was taken back to the lab and frozen for ID, sorting, and dry weight estimation by taxon. This time period (2016-2023) saw decreasing SAV coverage and decreasing number of sites with vegetation. The cause of diminishing SAV coverage in the preserve is being investigated, but expert hypotheses include herbivory by common carp, herbivory by swans, and frequency of low water levels at the Emiquon Preserve over the past five years (UIS, 2023).

From 2010-2015, SAV density was estimated by percent coverage on a vegetation rake, while emergent, non-rooted floating-leaved, and rooted floating-leaved aquatic vegetation density was estimated by percent cover observed within a 2 m perimeter around the boat. All aquatic vegetation data were collected according to LTRM aquatic vegetation monitoring protocols of Yin et al. (2000). Aquatic vegetation was sampled from May-September at both Thompson and Flag lakes, which were sampled as one water body, but spatially stratified into north, middle, and south units. The number of sites sampled per unit was proportional to the surface area of each unit and was determined monthly. Sampling was conducted at 30 random sites each month during May, June, and September, but at 60 random sites each month in July and August, during the peak of the growing season.

During 2008-2009, aquatic vegetation was monitored using random littoral (<15 m from the shoreline) and pelagic (>15 m from the shoreline) areas at Thompson Lake. Sampling was conducted monthly at five random littoral and pelagic sites each during April-October and at 20 random littoral and pelagic sites each in July during the peak of the growing season. Additionally, three east/west fixed site transects were sampled monthly at seven locations along each transect for SAV vegetation from May-October. Full-scale aquatic vegetation monitoring was not conducted in 2007 to reduce boat disturbance caused by plant collections and to allow establishment of SAV during the first year of restoration. However, it should be noted that SAV plant species were visually detected at Thompson Lake in 2007 during fish monitoring.

Fish Monitoring

Monthly sampling occurred from April-October from 2009-2023 (with the exception of two years with reduced months of sampling: 2016 and 2020). Monthly sampling used a multiple gear approach at random and fixed sites. Effort for each full sampling year included: 28 electrofishing runs (15 minutes of effort per site, ~200 m, 4/month), 28 fyke net sets (~24 hours each, 4/month), and 28 mini-fyke net sets (~24 hours each, 4/month) at shoreline or pseudo-

shoreline (used for shoreline gear) sites for the sampling season. In 2016, sampling was limited to July through October due to staff turnover, but the effort per month and methods used during those months were the same as during 2009 and 2019. In 2020, sampling only occurred from May-October due to sampling restrictions put in place by the University of Illinois in response to the Covid-19 pandemic. Despite not sampling in April 2020 for these reasons, monthly effort and methods remained the same as other years. All gears were fished according to the LTRM fish monitoring protocols of Ratcliff et al. (2014).

Seven tandem fyke net sets (~24 hours each) and seven tandem mini-fyke net sets (~24 hours each) were deployed at open water (pelagic) sites from 2009-2015 until tandem net sets were discontinued due to high mortality of sportfish. Minnow traps were discontinued in 2009 because they were less effective than mini-fyke nets. These gears were stratified to give a balanced assessment of the major habitats (shoreline, open water, and ditch).

Fish sampling in 2007 and 2008 differed due to water surface elevation at Emiquon. For instance, in 2007, sampling was conducted July-November (excluding September) using a multiple gear approach at fixed sites including: nine pulsed-DC electrofishing runs (15 minutes each), 12 fyke net sets (~24 hours each), 12 mini-fyke net sets (~24 hours each), and 25 minnow trap sets (~24 hours each) at shoreline or pseudo-shoreline (used for shoreline gear) sites. Also, two tandem fyke net sets (~24 hours each), two tandem mini-fyke net sets (~24 hours each), one trammel net set (1.5 hours) and one experimental gill net set (1.5 hours) were deployed at open water (pelagic) sites. By comparison, sampling in 2008 was conducted April-October at Thompson Lake using a multiple gear approach at random and fixed sites including: 28 electrofishing runs (15 minutes each), 28 fyke net sets (~24 hours each), 28 mini-fyke net sets (~24 hours each), and 25 monthly minnow trap sets (~24 hours each) at shoreline or pseudo-shoreline (used for shoreline gear) sites. Seven tandem fyke net sets (~24 hours each) and seven tandem mini-fyke net sets (~24 hours each) were deployed at open water (pelagic) sites. Flag Lake was also sampled with two electrofishing runs (15 minutes each). Gill and trammel nets became fouled by aquatic vegetation and algae in 2007 and were discontinued in 2008.

Key Ecological Attributes (KEAs) Results for Submersed Aquatic Vegetation

KEA 1: Underwater Irradiance

Indicator: Secchi disc transparency

Desired Range: In submersed aquatic vegetation target areas, where water depth is ≤ 1.5 m, Secchi disc reading should be ≥ half the maximum water depth during late spring/early summer.

Goal Met:

Met: 2007-2011, 2013-2017, and 2019

Not met: 2012, 2018, 2020-2023

Not measured:

Notes:

In some of the years since the box sampler has been in use for vegetation sampling, insufficient numbers of water quality parameter samples were collected for calculation of KEA 1 from vegetation surveys. These reduced sample numbers were due: 1) to fewer sites being visited in some years due to reduced SAV coverage in the Emiquon Preserve, and 2) to some sites with SAV being so shallow that water quality parameters were unobtainable (e.g., two sites from which SAV was collected in 2021 were only 0.06 m deep). Therefore, calculation of KEA 1 has used water quality data from fish monitoring sites ≤ 1.5 m deep since the annual report for 2018.

- In 2023, average water depth and Secchi depth (underwater irradiance) at sampling sites remained similar to values during 2021 and 2022, so that the ratio of secchi depth to water depth also remained low (Figs. 1-3).
- Only 4 samples were obtained in 2016, two were above the KEA goal and two were below.
- Secchi disc transparency met the desired KEA range (> 50% of the time) in most years from June – August (Figs. 1 and 3) except in 2012 when a seasonal drought occurred, and 2018, 2020, and 2021 when water level management reduced water levels, and 2022.
- Reference water quality data (i.e., water temperature, dissolved oxygen, depth, and Secchi disc transparency) can be found in Tables 1 and 2.

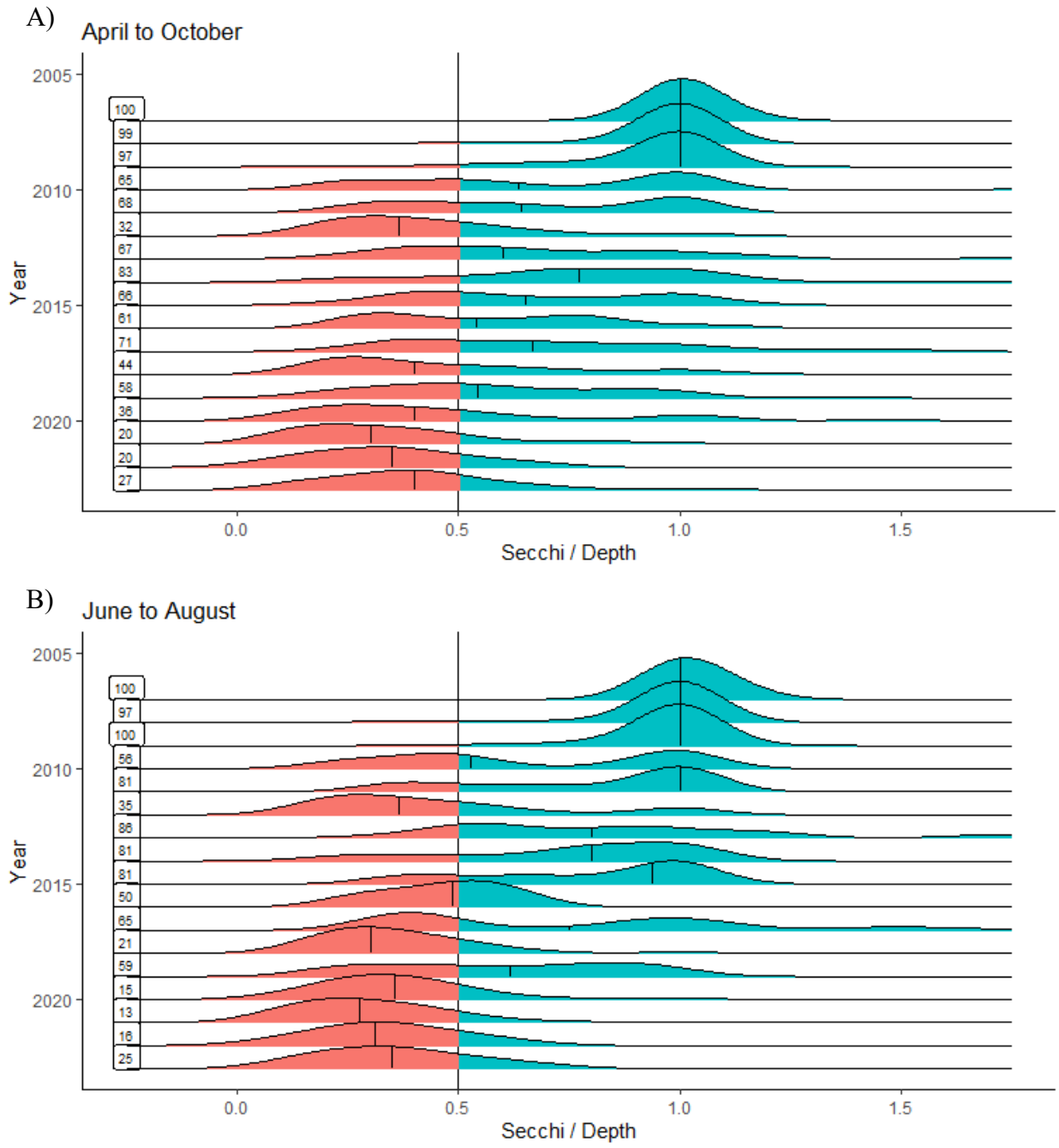

Figure 1. Distribution of ratios of Secchi disc transparencies to water depths at sites by year, with 0.5 (vertical line) as the threshold above which KEA 1 is met; area under the curve in red indicates percent of time below KEA threshold and area under the curve in blue, above threshold. Boxed values along the y-axis in white are the percentage of time the KEA was met during each year (i.e., the proportion of the area under that year's distribution curve which was above the 0.5 Secchi / Depth ratio. Panel A is based on data from April-October at Emiquon from 2007-2019, and 2021-2023, and from May-October in 2020 due to the Covid-19 pandemic. Panel B is based on data from June-August at Emiquon from 2007-2023. Transparency decreased during periods of low water (a natural drought in 2012 and drawdowns in 2018, 2020, and 2021), and remained low through 2023.

Table 1. Average water quality reading from fish sites where Secchi and water depth was measured from 2007-2023, and where depth ≤ 1.5 m. This is in reference to KEA 1. for measuring underwater irradiance.

Year	Water Temperature (°C)	Dissolved Oxygen (ppm)	Depth (m)	Secchi (cm)
2007	17.2	7.50	0.84	85.2
2008	21.5	7.52	0.65	62.6
2009	20.7	7.94	0.80	72.8
2010	23.0	7.97	0.72	42.4
2011	21.4	6.65	0.75	45.3
2012	20.3	7.73	0.84	33.1
2013	21.1	7.26	0.74	44.3
2014	20.3	8.18	0.74	55.4
2015	20.9	6.73	0.90	57.1
2016	22.2	8.55	1.03	53.8
2017	21.7	6.76	0.59	40.9
2018	21.9	8.60	0.49	19.6
2019	21.7	8.06	0.70	38.0
2020	21.9	9.90	0.75	31.6
2021	20.6	9.44	0.73	20.2
2022	22.1	8.56	0.74	21.1
2023	23.7	8.15	0.61	20.9

Table 2. Average water quality readings from vegetation surveys throughout the Emiquon Preserve from box sampler from 2016-2023, for sites <1.5 m, and (since 2022) recorded even when no veg was present at site. Water quality samples could not be taken at every site in 2021 due to extremely low water levels.

Year	Water Temperature (°C)	Dissolved Oxygen (ppm)	Depth (m)	Secchi (cm)
2016	18.5	7.5	Not taken	58.9
2017	25.5	5.5	1.08	80.9
2018	24.2	6.4	0.14	13.2
2019	26.8	4.7	0.86	49.6
2020	26.2	3.8	0.25	12.1
2021	25.1	4.6	0.27	10.5
2022	28.5	5.0	0.55	16.8
2023	23.1	7.9	0.73	16.4

KEA 2: Hydrology

Indicator: Water depth

Desired Range: Rate of water rise should not exceed 1.5 cm/day during the growing season (May-September); water level fluctuations (rise) should not exceed 1 m total (May-September)

Goal Met:

Met: 2007-2023

Not met:

Not measured:

Notes:

Daily water gauge data were collected and provided by TNC from the Emiquon pumphouse.

- Interpolating linearly during days when no data were collected, and excluding days that were not within growing season (May-September), the water level rose < 1.5 cm/day, 88-97% of the growing season in each year from 2007-2023 (Fig 3) and the water level never exceed 1 m. To meet the KEA, water level rise >1.5 cm/day must occur more than 25% of the growing season days in the year. Therefore, this KEA is considered to be met for all years from 2007-2023.

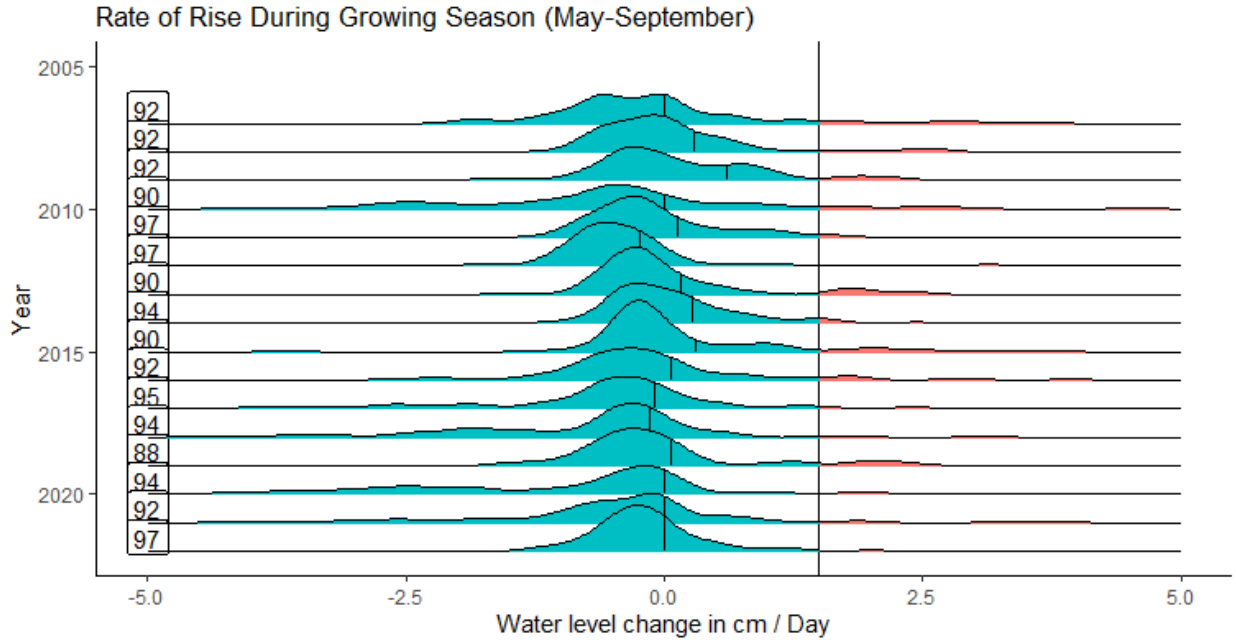

Figure 2. Percentage of days on which the water level rose a given amount in cm/day at the Emiquon preserve. The percentage of days when water rose more than 1.5 cm per day is denoted by the vertical line and the red area under the curves to the right of this line. Water level rise more than 1.5 cm exceeded 10% of growing season days only in 2015. Graph ranges from 2007-2023.

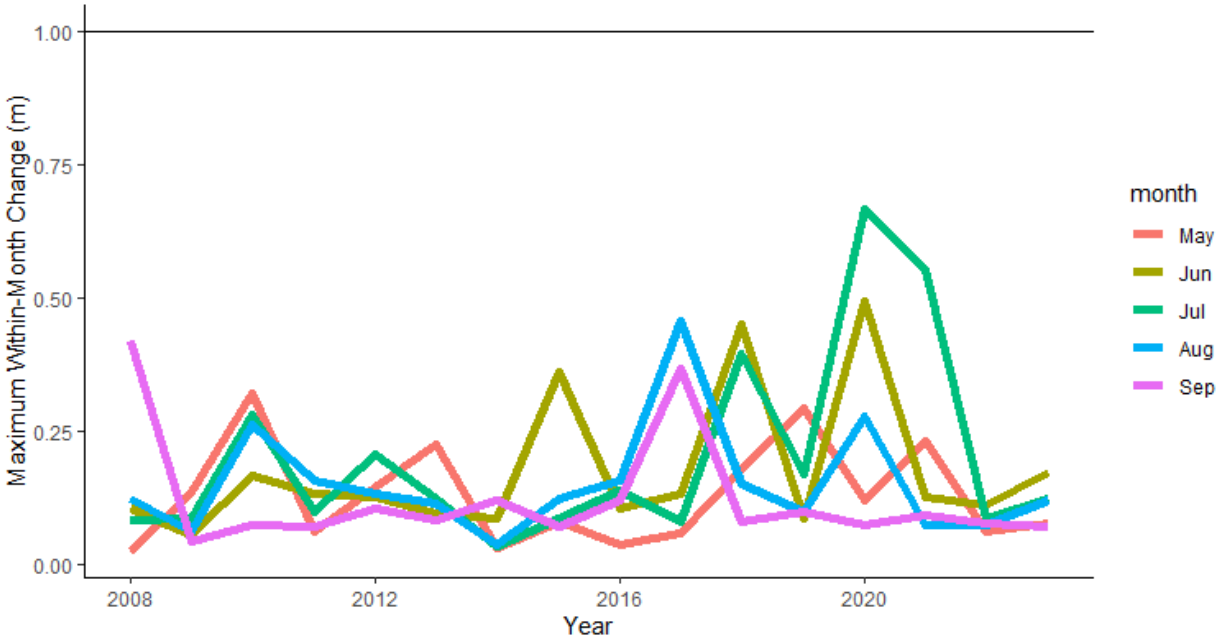

Figure 3. Monthly change of water levels from May to September using water gage data at Emiquon. The horizontal line at 1 m represents the value below which KEA 2 indicates the preserve should operate. This goal has been met from 2008 to 2023. The three highest records are from June and July of 2020 and July of 2021.

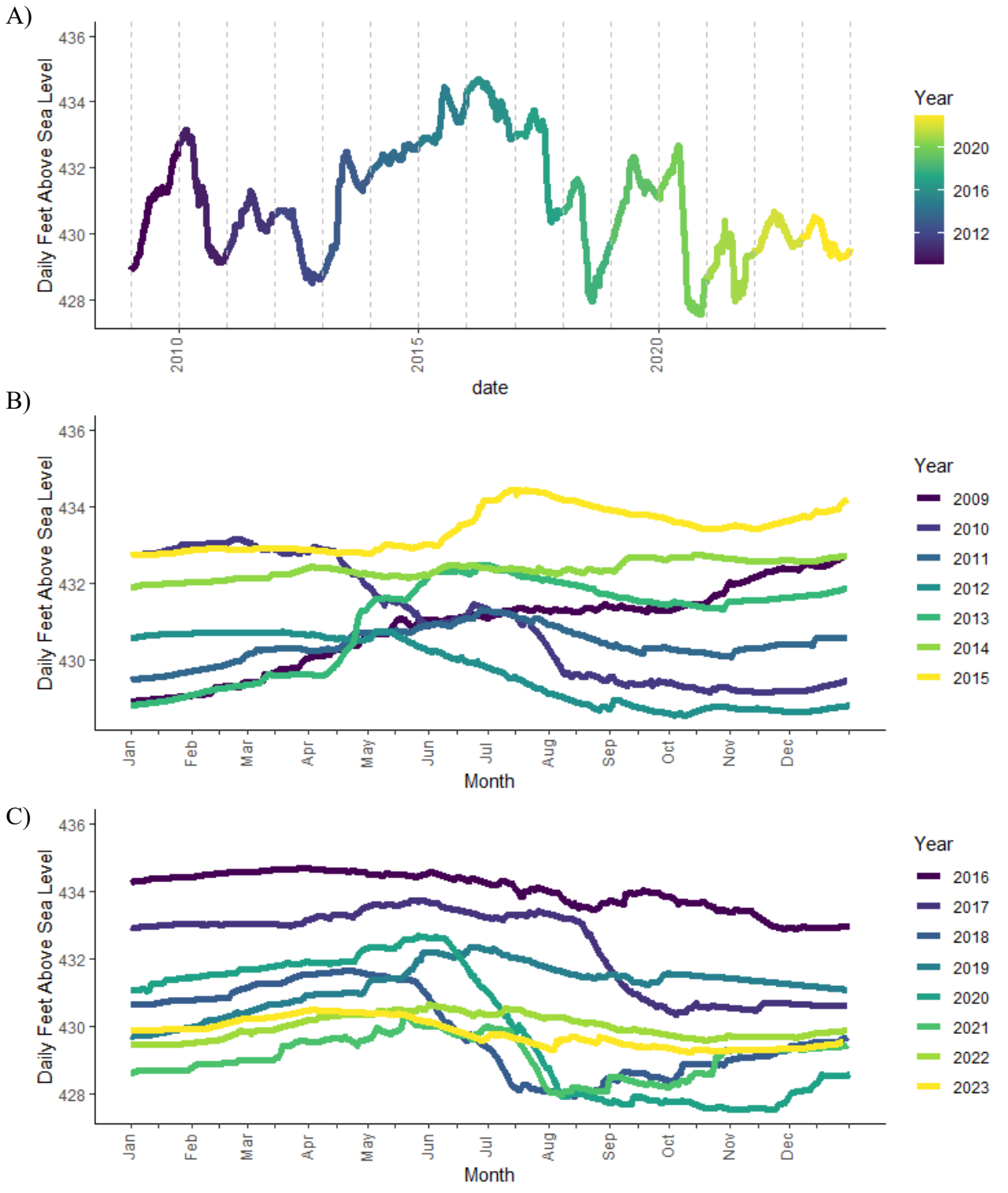

Figure 4. Average daily water level during six years of management at Emiquon as function of year (panel A) and day of year (panels B and C) from 2009-2023 (panel A), 2009-2015 (panel b), and 2016-2023 (panel C). A drought occurred in 2012, and drawdowns occurred in 2018, 2020, and 2021.

KEA 3: Community Composition

Indicator: Percent native vs. invasive

Desired Range: ≤10% exotics, e.g., Eurasian watermilfoil (*Myriophyllum spicatum*), curly-leaf pondweed *Potamogeton crispus*

Goal Met:

Met: 2008, 2009, 2018, and 2019

Not met: 2010- 2017, and 2020-2021, 2023

Not measured: 2007 and 2022

Notes:

Vegetation samples were collected during the peak of the growing season using the Forbes box sampler method from 2016-2023, and using the LTRM rake sampler method from 2008-2015, and again in 2023. SAV density (where SAV was present) in 2021-2023 was only about 20% of those during 2016-2020, and only about 10% of densities during peak density years of 2010-2015. This is compounded by a 5- to 15-fold reduction in areal coverage of Emiquon by SAV in 2018 and 2020-present (Blodgett et al., 2023).

- In 2023, only a total of 11 sites visited during the box sampler survey had aquatic vegetation of any type (mostly floating American lotus, non-rooted floating duckweed (*Lemna sp.*), and filamentous algae). Of these, only 3 had submersed aquatic vegetation, of which only 2 were brought back to the lab for analysis (the third was so sparsely vegetated with longleaf pondweed and sago pondweed (*Potamogeton pectinatus*) that they were not captured by the box sampler when deployed).
- Please note for figure 6 and 7 and for table 4, that excluding ditches from 2022 would give a biomass of 8.87 g/m^2 for *Potamogeton nodosus* and 0.184 g/m^2 for *Ceratophyllum demersum*, which makes for a total 9.05 g/m^2 of 100% native SAV. However, these non-ditch numbers are from only three sites in South Flag lake and probably do not well represent expansive shallower-water portions of north and south flag lake in 2022.

Table 3. Number of sites visited and having vegetation in each of the three submerged aquatic vegetation surveys in 2023. Numerators indicate the number of sites visited, while denominators indicate the number of sites available. Sites not visited were either inaccessible/terrestrial (primary sites), or obviously open water sites (alternate sites). The number in the parentheses indicate the number of sites in each group which had SAV present at that site in sufficient numbers to be collected by the box or rake samplers. Note that In 2023, only a total of 11 sites visited during the box sampler survey had aquatic vegetation of any type (mostly floating American lotus (Nelumbo lutea), non-rooted floating duckweed (Lemna sp.), and filamentous algae). Of these, only 3 had submersed aquatic vegetation, of which only 2 were brought back to the lab for analysis (the third was so sparsely vegetated with longleaf pondweed and sago pondweed that they were not captured by the box sampler when deployed).

Survey	*Box Veg*	*Aug Rake Veg*	*Sep Rake Veg*
Primary Sites Visited	*29/30 (1)*	*57/60 (10)*	*29/30 (10)*
Alternate Sites Visited	*11/30 (1)*	*23/58 (9)*	*13/30 (9)*
Total Sites Visited	*40/30 (2)*	*80/60 (19)*	*42/30 (19)*
Sites with SAV	*3*	*19*	*19*

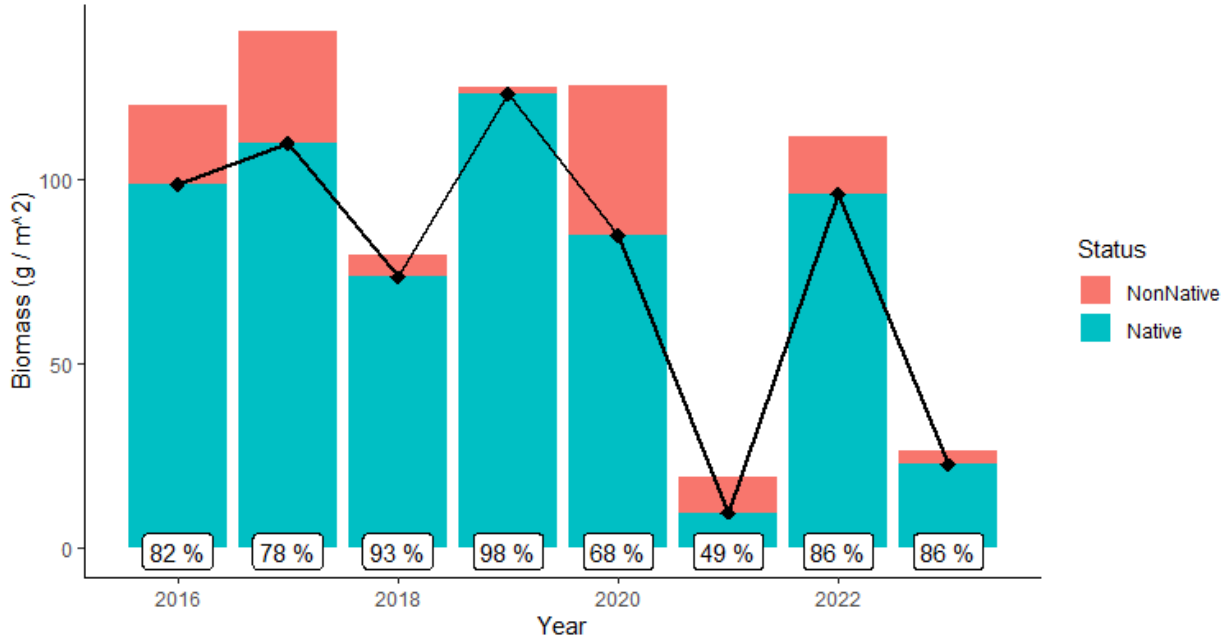

Figure 5. Mean areal biomass of native and non-native submersed aquatic vegetation using the box sampler from 2016-2023 at Emiquon, with percent native areal biomass included as values below each column. Native vegetation abundance decreased over the last several years to 49% in 2021, but rebounded in 2022 and 2023. The spike in 2022 abundance reflects high representation of ditch sites in that year. (Excluding ditches from 2022 would give a biomass of 9.05 g/m^2 and 100% native; However, these numbers are only from three sites in South Flag lake and probably did not well represent expansive shallower-water portions of north and south flag lake).

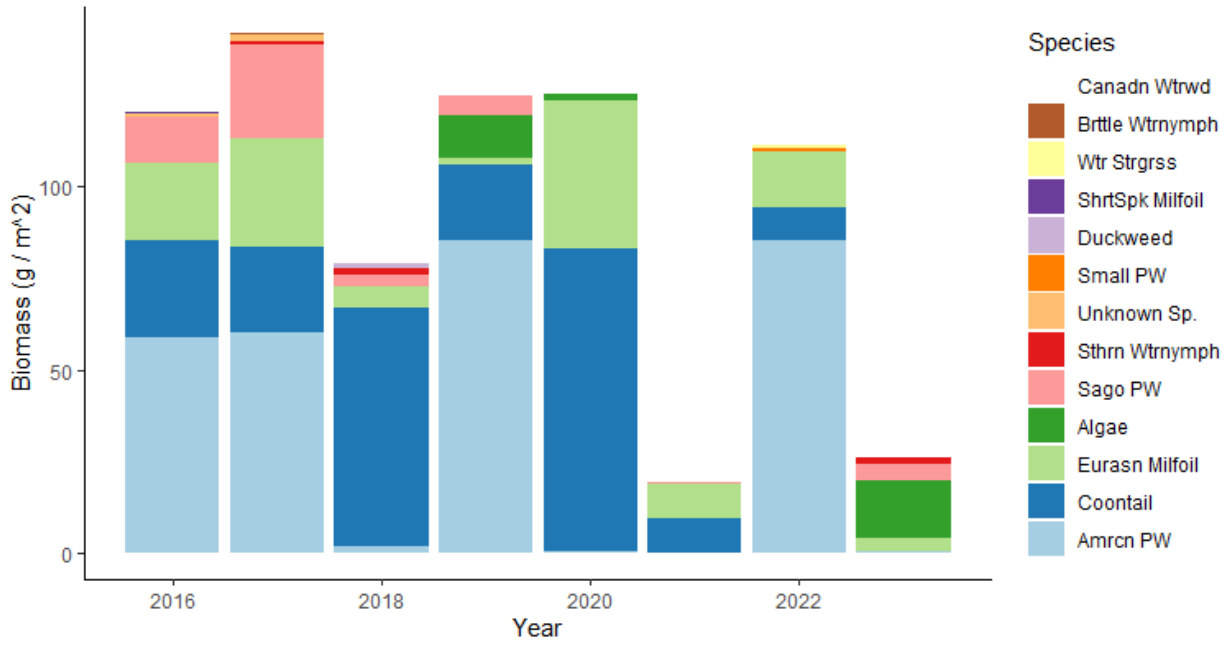

Figure 6. Areal biomass composition of submerged aquatic vegetation at Emiquon determined from all sites sampled using the box sampler from 2016-2023. The spike in 2022 abundance (especially for Potamogeton nodosus*) reflects high representation of ditch sites in that year. (Excluding ditches from 2022 would give a biomass of 8.87 g/m^2 for* P. nodosus *and 0.184 g/m^2 for* Ceratophyllum demersum*); However, these numbers are only from three sites in South Flag lake and probably did not well represent expansive shallower-water portions of north and south flag lake).*

Table 4. Annual areal dry-weight biomass (g/m^2) of submerged aquatic vegetation species at Emiquon determined from all sites sampled using the box sampler from 2016-2023. Water level management initially increased the abundance of coontail but also reduced observations of naiads and pondweeds. Because of over-representative sampling of ditch habitats in 2022, we also include in parentheses the values for 2022 when excluding 5 ditch sites (leaving 3 sites in south flag lake). Even the 3 sites all from South Flag Lake are probably not representative of the more expansive shallow areas of north flag lake and the perimeter of Thompson Lake in 2022.

Common Name	Scientific Name	USDA Code	2016	2017	2018	2019	2020	2021	2022	2023	Mean
Longleaf Pondweed	Potamogeton nodosus	PONO2	59.0	60.2	1.2	85.3	0.4	0	85.5 (8.87)	0.48	36.6
Coontail	Ceratophyllum demersum	CEDE4	26.5	23.2	65.1	20.6	82.8	9.4	8.9 (0.184)	0	25.6
Eurasian Milfoil	Myriophyllum spicatum	MYSP2	21.1	30.0	5.9	2.0	40.5	9.8	15.3 (0)	3.8	16.0
Sago Pondweed	Potamogeton pectinatus	POPE6	12.4	25.4	2.9	5.3	0.02	0.01	0 (0)	4.8	6.4
Algae	Algae	ALGA	0	0	0	11.6	1.5	0	0 (0)	15.4	3.6
Southern Naiad	Najas guadalupensis	NAGU	0	0.78	2.0	0	0	0	0 (0)	1.8	0.57
Duckweed	Lemna sp.	LEMN	0	0	1.4	0	0	0.047	0 (0)	0	0.18
Small Pondweed	Potamogeton pucillis	POPU7	0	0	0	0	0	0	0.83 (0)	0	0.10
Water Stargrass	Heteranthia dubia	ZODU	0	0.1	0	0	0	0.0068	0.70 (0)	0	0.094
Northern Milfoil	Myriophyllum sibiricum	MYSI	0.60	0	0	0.003	0	0	0 (0)	0	0.075
Brittle Naiad	Najas minor	NAMI	0	0.45	0.010	0	0	0	0.028 (0)	0	0.060
Canadian Waterweed	Elodia canadensis	ELCA7	0	0	0.022	0	0	0	0 (0)	0	0. 0028
Unidentified	NA	UNKNOWN	0.91	2.0	0	0	0	0	0 ()	0	0.36
Period Totals			120.6	142.1	79.2	124.9	125.2	19.2	111.3 (9.05)	26.3	

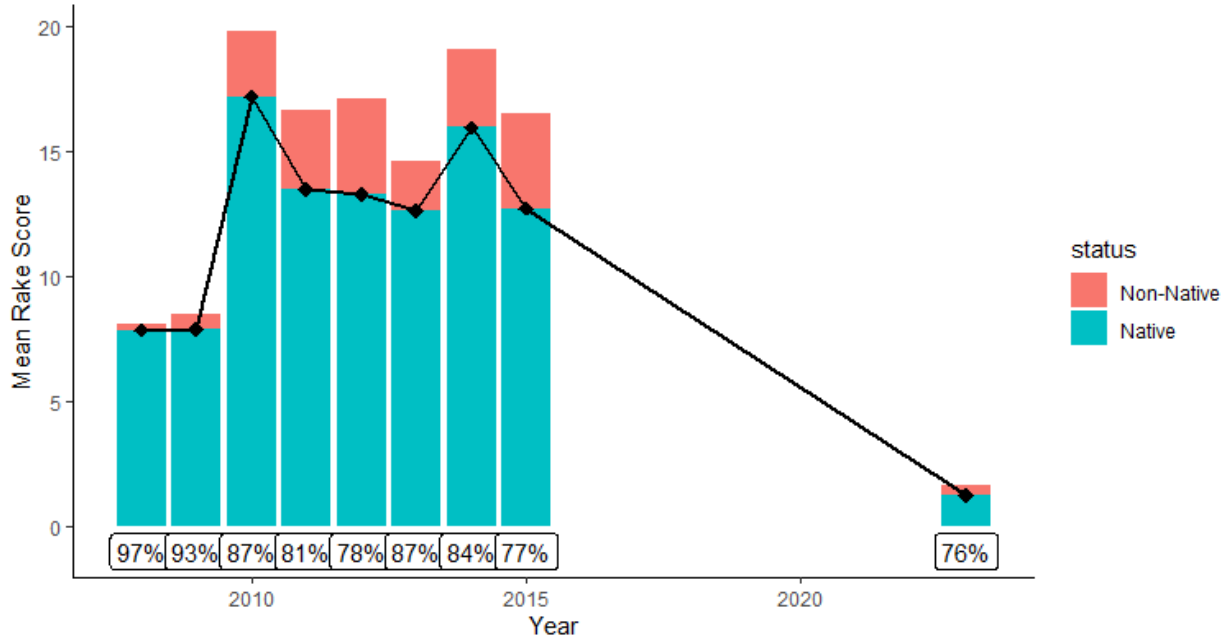

Figure 7. Additive density rating (ADR: sum of 6 quadrat rake scores for a site, see Yin and Kreiling, 2011) of native and non-native submerged aquatic vegetation at Emiquon determined from all sites sampled during August-September using the LTRM rake sampler from 2008-2015 and 2023, with percent native ADR included as values below each column.

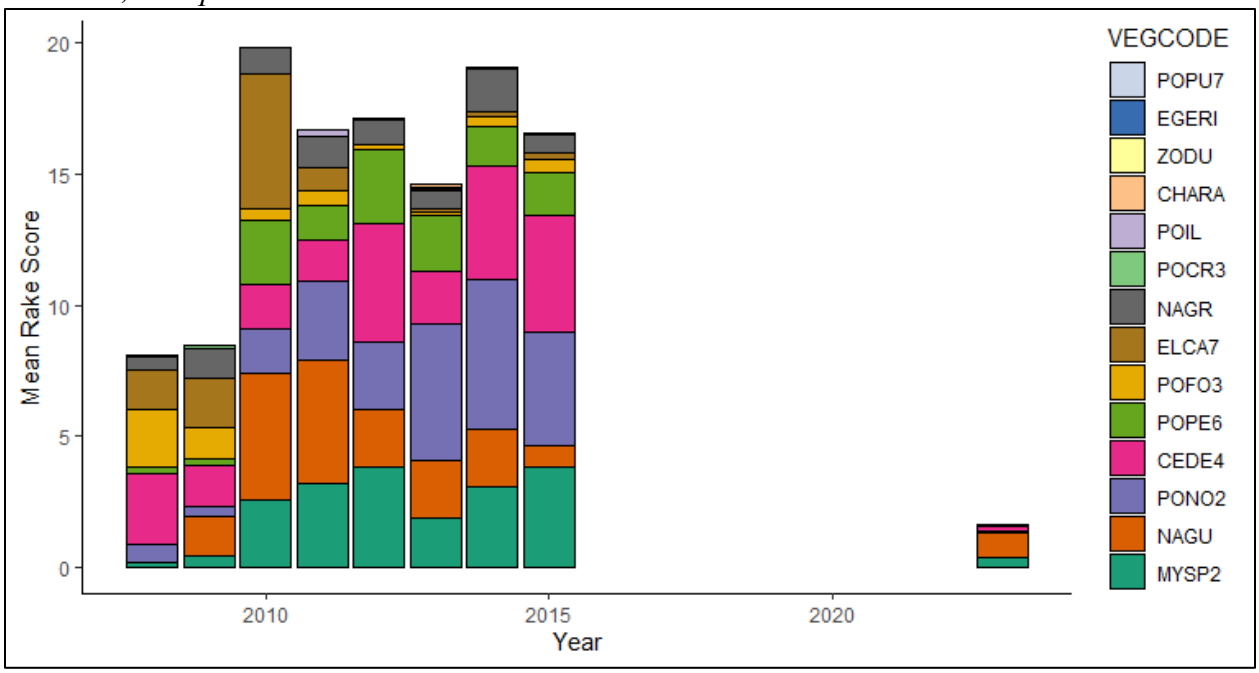

Figure 8. Additive density rating (ADR: sum of 6 quadrat rake scores for a site, see Yin and Kreiling, 2011) by taxa of submerged aquatic vegetation (official USDA plant 'symbol' code, also referenced by common name in Table 5) at Emiquon determined from all sites sampled during August-September using the LTRM rake sampler from 2008-2015 and 2023. Mean rake scores were calculated as average mean rake score across quadrats at a site, and grand means taken across all sites for each year. All values can be found in Table 5.

Table 5. Additive density rating (ADR: sum of 6 quadrat rake scores for a site, see Yin and Kreiling, 2011) by taxa of submerged aquatic vegetation at Emiquon determined from all sites sampled during August-September using the LTRM rake sampler from 2008-2015 and 2023. Mean rake scores were calculated as average mean rake score across quadrats at a site, and grand means taken across all sites for each year.

Common Name	Scientific Name	USDA Code	2008	2009	2010	2011	2012	2013	2014	2015	Mean 08-15	2023	Mean
Eurasian Milfoil	Myriophyllum spicatum	MYSP2	0.178	0.21	2.33	3.28	4.50	1.89	3.59	4.14	2.50	0.40	2.30
Southern Naiad	Najas guadalupensis	NAGU	0	0.94	5.14	4.77	3.90	1.63	1.85	0.92	2.40	0.93	2.20
Longleaf Pondweed	Potamogeton nodosus	PONO2	0.49	0.30	1.49	3.00	2.15	3.83	4.72	3.34	2.40	0.046	2.20
Coontail	Ceratophyllum demersum	CEDE4	1.90	1.53	1.39	1.24	3.11	1.41	3.09	4.38	2.30	0.22	2.00
Sago Pondweed	Potamogeton pectinatus	POPE6	0.26	0.38	1.90	1.85	2.31	1.69	1.60	1.72	1.50	0.057	1.30
Leafy Pondweed	Potamogeton foliosus	POFO3	1.83	1.42	2.10	1.67	1.07	0.58	0.96	1.11	1.30	0	1.20
Canadian Waterweed	Elodia canadensis	ELCA7	0.96	1.54	4.77	0.96	0.21	0.11	0.17	0.24	1.10	0	0.99
Small Pondweed	Potamogeton pucillis	POPU7	0.35	0.48	1.19	0.97	1.12	0.42	0.93	0.72	0.77	0	0.69
Curly-leaf Pondweed	Potamogeton crispus	POCR3	0.13	0.13	0.076	0.071	0.038	0.029	0.0048	0.048	0.065	0	0.058
Illinois Pondweed	Potamogeton illinoensis	POIL	0	0	0	0.17	0.11	0.029	0.0048	0.16	0.059	0	0.052
Chara sp.	Chara sp.	CHARA	0	0	0	0.033	0.095	0.063	0.038	0	0.029	0	0.025
Water Stargrass	Heteranthia dubia	ZODU	0	0	0	0	0.0048	0	0.0049	0.0097	0.0024	0	0.0021
Egeria sp.	Egeria sp.	EGERI	0.0096	0	0	0	0	0.0048	0	0	0.0018	0	0.0016
Northern Milfoil	Myriophyllum sibiricum.	MYSI	0	0	0	0	0	0	0.0095	0	0.0012	0	0.0011
Brittle Naiad	Najas minor	NAMI	0	0	0	0	0	0	0	0	0	0.17	0.019
Period Totals			6.10	6.93	20.4	18.0	18.6	11.7	17.0	16.8	14.4	1.83	13.0

Key Ecological Attributes (KEAs) Results for Emergent and Floating Leaved Plants

KEA 4: Hydrology

Indicator: Stable water depth

Desired Range: Rate of water rise does not exceed 1.5 cm/day during the growing season (May-September); Water level fluctuations (rise) do not exceed 1 m total (May-September)

Goal Met:

Met: 2007-2023

Not met:

Not measured:

Notes:

See KEA 2, which has the same metrics and the same goals for those metrics.

KEA 5: Community Composition

Indicator: Percent natives vs. invasive

Desired Range: ≥90% dominance by native species

Goal Met:

Met: 2008-2023

Not met:

Not measured: 2007

Notes:

While we have sampled the submerged aquatic vegetation communities at Emiquon from 2007 to the present, we have not sampled emergent nor floating-leaved aquatic vegetation communities at Emiquon since abandoning the Rake method last used in 2015 for the box sampler method in 2016. That said – dominance of native emergent and floating-leaved species has been apparent anecdotally even when not measured in the field. Native emergent and floating-leaved species have primarily included Cattail (*Typha sp.*), American Lotus, Willow (*Salix sp.*), Duckweed, and primrose/seedbox (*Ludwigia sp.*). A caution noted by a *Typha* expert that the *Typha sp.* dominating portions of the preserve could be a native-invasive hybrid would be worth investigating during 2024.

Key Ecological Attributes (KEAs) Results for Fish Assemblage

KEA 6: Fish Community Assemblage

Indicator: Number of native species populations

Desired Range: ≥25 native species represented (very good = ≥30 native species)

Goal Met:

Met: 2019-2023

Not met: 2007-2018

Not measured:

Notes:

The number of native fish species was calculated from the total catch of all fish from all gear types in each year.

- During 2023 sampling, 25 native species were collected, meeting the goal of 25 species or more (Fig 12).
- In 2023, four species were noted by commercial fishing catches that were not detected in our sampling gears: paddlefish, silver carp, bighead carp, and grass carp.
- The desired range of 25 native species was met in 2018 for the first time since restoration occurred (n=25) (Fig 12).
- Since 2007, a total of 38 unique native species and 3 non-native species have been collected in monitoring samples. Furthermore, 16 new species were detected since the levee overtopped in 2013 (Table 6).
- Non-native fish species captured using standardized fish methods include common carp, silver carp, and goldfish.
- A total of 41 species (not including hybrids nor unidentified groups) have been observed in the Emiquon Preserve in monitoring sampling, with a program-average catch of 119 fish per sampling event using daytime electrofishing, fyke net, or minifyke net gears. These data do not include tandem fyke tandem minifyke, nor gillnets. (Table 7).

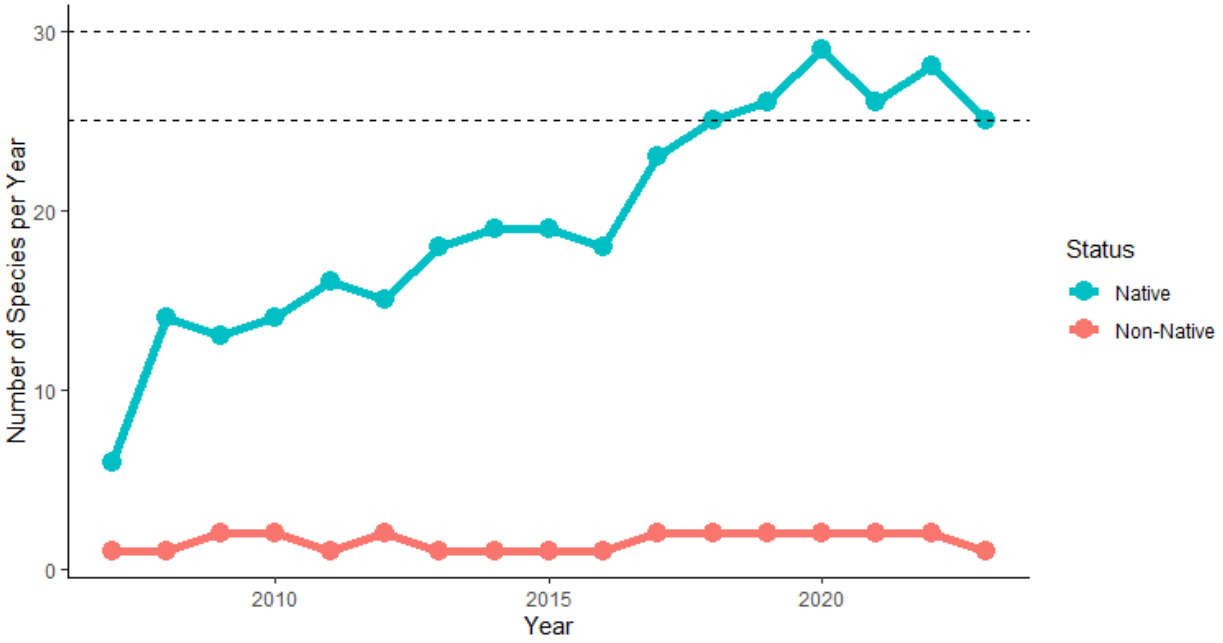

Figure 9. Fish collect at all sites (fixed and random) using all gears from 2007-2023 at Emiquon. Blue indicates native species and red is non-native species (common carp, goldfish, and bigheaded carp spp (silver and bighead carp)). The number of fish detected annually has increased since restoration, and cumulatively a total of 38 native and 3 non-native species have been collected to date.

*Table 6. New fish species observed since 2012 (year prior to levee overtopping in 2013), during standard sampling. Species in this table whose common name has not yet been linked to a scientific name include: black buffalo (*Ictiobus niger*), brook silverside (*Labidesthes sicculus*), bluntnose minnow (*Pimephales notatus*), grass pickerel (*Esox americanus*), mud darter (*Eutheostoma asprigene*), river shiner (*Notropis blennius*), sauger (*Sander canadensis*), smallmouth buffalo (*Ictiobus bubalus*), spottail shiner (*Notropis hudsonius*).*

Year	alligator gar	black buffalo	*brook silverside	bigmouth buffalo	bluntnose minnow	*channel catfish	freshwater drum	*grass pickerel	mud darter	river shiner	*sauger	smallmouth buffalo	spottail shiner	**silver carp**	white bass	yellow bass
2012						X										
2013									X		X					
2014				X			X	X								
2015				X		X	X	X								
2016																
2017		X		X		X	X	X		X				**X**		X
2018			X	X		X	X					X		**X**	X	X
2019		X	X	X		X	X						X	**X**	X	X
2020	X	X	X	X		X	X					X	X	**X**	X	X
2021		X	X	X	X	X	X					X			X	X
2022		X	X	X		X	X	X				X		**X**	X	X
2023			X	X		X	X		X			X		**X**	X	X

*indicates fish that were initially stocked but not collected until 2012 or later.

*Table 7. Annual, mean catch of fish species per sampling event (D, M, or F), with total mean catch per sampling event across all species and with mean annual catch per sampling event across all years for each species and for total catch. Species in this table whose common name has not yet been linked to a scientific name include: emerald shiner (*Notropis atherinoides*), warmouth (*Lepomis gluosus*), starhead topminnow (*Fundulus dispar*), black bullhead (*Ameiurus melas*), brown bullhead (*A. nebulosus*), yellow bullhead (*A. natalis*), goldfish (*Carassius auratus*), green sunfish (*Lepomis cyanellus*), orangespot sunfish (*L. humilis*), redear sunfish (*L. microlophus*), lake chubsucker (*Erimyzon sucetta*).*

Species	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Mean
Bluegill	0.545	49.4	50.2	38.9	56.5	22.2	44.2	53.6	31.4	20.5	19.6	39.9	11.0	39.9	5.26	9.40	21.0	30.2
Unidentified (usually YOY) Centrarchids	-	288.7	22.4	73.1	-	-	-	0.238	-	-	-	-	0.012	2.27	13.7	7.02	11.4	24.6
Gizzard Shad	-	-	0.060	4.94	2.77	19.1	92.8	31.6	17.8	20.8	33.8	44.8	75.8	22.3	21.4	15.8	13.3	24.5
Largemouth Bass	30.5	10.8	9.52	8.68	4.57	21.2	5.38	6.15	6.40	3.70	34.1	6.91	2.55	6.44	2.70	1.24	0.952	9.52
Black Crappie	2.33	1.78	17.2	3.17	1.17	4.37	29.9	4.70	5.54	8.13	3.94	5.55	11.1	10.2	4.90	4.56	3.76	7.19
Golden Shiner	-	-	-	0.269	0.238	24.1	5.83	3.38	3.35	0.533	2.55	32.3	7.15	13.5	8.88	1.18	1.11	6.14
Yellow Bass	-	-	-	-	-	-	-	-	-	0.033	0.024	0.293	4.71	8.21	40.9	7.94	16.7	4.64
Pumpkinseed	0.091	12.3	7.57	8.95	3.77	2.31	1.46	4.86	3.33	13.1	2.63	0.756	0.881	1.09	0.198	0.131	0.167	3.74
Brook Silverside	-	-	-	-	-	-	-	-	-	-	-	0.012	0.238	4.81	8.46	9.98	2.15	1.51
Mosquitofish	-	0.125	0.119	-	0.131	0.571	-	-	-	-	-	0.012	0.071	0.114	0.086	0.429	22.7	1.43
Bowfin	0.152	0.075	0.155	0.256	0.131	0.333	0.713	0.464	0.518	0.333	1.07	3.13	1.75	2.54	1.53	2.12	2.15	1.03
Emerald Shiner	-	0.013	-	-	-	-	0.013	-	-	0.033	3.32	12.1	0.226	0.129	0.123	0.012	0.060	0.944
Common Carp	0.030	-	0.690	0.551	1.69	0.488	0.988	0.405	0.277	0.233	0.317	1.04	0.607	0.543	1.35	0.643	0.333	0.599
White Crappie	0.030	0.025	-	-	0.012	0.095	0.35	0.179	0.518	0.467	0.268	1.71	0.548	0.457	1.57	1.04	1.37	0.508
White Bass	-	-	-	-	-	-	-	-	-	-	-	0.268	4.98	0.200	0.827	0.179	0.548	0.412
Unidentified (usually YOY) Catostomids	-	-	-	-	-	-	0.038	-	-	-	0.037	4.05	-	0.100	0.173	0.286	-	0.275
Age-0 (Young-Of-Year) Fish	-	-	-	-	-	-	-	-	-	-	-	4.17	-	-	-	-	-	0.245
Spotted Gar	-	0.013	0.036	0.026	0.119	0.357	0.175	0.536	0.398	0.100	0.707	0.049	0.5	0.357	0.099	0.345	0.036	0.226
Warmouth	-	0.488	0.226	0.615	0.214	0.048	0.038	0.25	0.602	0.133	0.195	0.024	0.048	0.129	0.074	0.048	0.298	0.202
Starhead Topminnow	-	-	-	-	0.024	0.917	0.200	0.905	0.06	0.067	0.098	0.049	0.238	0.443	0.012	0.19	0.226	0.202
Freshwater Drum	-	-	-	-	-	-	-	0.012	0.012	-	0.244	0.695	0.381	0.371	0.469	0.417	0.440	0.179
Unidentified Ictalurids	-	1.65	0.464	0.038	0.131	0.107	-	-	-	-	-	-	0.548	-	0.074	0.024	-	0.179
Shortnose Gar	-	-	-	0.013	-	-	0.213	0.214	0.108	0.033	0.256	0.073	0.702	0.5	0.148	0.155	0.107	0.148
Unidentified (usually YOY) Moronids	-	-	-	-	-	-	-	-	-	-	-	-	0.012	0.043	1.22	0.274	0.393	0.114
Unidentified Cyprinids	-	0.013	-	-	-	-	-	-	-	-	-	0.073	0.012	-	0.049	0.012	1.14	0.077
Black Bullhead	-	0.038	0.226	0.051	0.06	0.024	0.638	0.095	0.072	0.033	0.049	-	-	-	-	0.012	-	0.077
Longnose Gar	-	0.013	-	-	-	0.024	-	0.012	0.036	-	-	-	0.405	0.386	0.086	0.095	0.202	0.074

Species	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Mean
Channel Catfish	-	-	-	-	-	-	-	-	-	-	0.085	0.134	0.071	0.1	0.222	0.286	0.345	0.073
Brown Bullhead	-	-	0.071	0.013	0.012	-	0.025	0.012	0.036	0.067	0.195	0.159	0.06	0.043	0.062	0.107	0.036	0.053
Yellow Bullhead	-	-	-	-	0.024	0.06	0.063	-	0.036	0.1	0.073	0.11	0.083	0.029	-	0.012	0.012	0.035
Unidentified Fish (sometimes YOY)	-	-	-	-	-	-	-	-	-	-	-	-	0.524	-	-	-	0.048	0.034
Goldfish	-	0.288	0.012	0.013	-	0.024	-	-	-	-	-	-	-	-	0.012	-	-	0.020
Bigmouth Buffalo	-	-	-	-	-	-	-	0.012	0.012	-	0.037	0.037	0.071	0.071	0.012	0.036	0.036	0.019
Green Sunfish	-	0.125	0.083	-	0.048	-	-	-	-	-	-	0.012	-	-	-	-	-	0.016
Pumpkinseed x Bluegill Hybrid	-	-	-	0.013	0.012	-	0.013	0.012	-	-	-	0.012	-	-	-	0.143	0.036	0.014
Silver Carp	-	-	-	-	-	-	-	-	-	-	0.024	0.024	0.083	0.014	-	0.036	0.012	0.011
Smallmouth Buffalo	-	-	-	-	-	-	-	-	-	-	-	0.024	-	0.029	0.025	0.024	-	0.0067
Orangespot Sunfish	-	-	-	0.038	-	-	-	-	-	0.033	-	-	0.024	0.014	-	-	-	0.0065
Unidentified (usually YOY) Gar	-	-	-	-	-	-	-	-	-	-	-	0.012	0.024	-	0.049	0.024	-	0.0064
Green Sunfish x Pumpkinseed hybrid	-	-	0.083	0.026	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0064
Black Buffalo	-	-	-	-	-	-	-	-	-	-	0.012	-	0.024	0.014	0.012	0.024	-	0.0051
Common Carp x Goldfish Hybrid	-	-	-	-	-	-	-	0.012	-	-	0.012	0.024	-	0.029	-	-	-	0.0045
Grass Pickerel	-	-	-	-	-	-	-	0.012	0.024	-	0.012	-	-	-	-	0.012	-	0.0035
Spottail Shiner	-	-	-	-	-	-	-	-	-	-	-	-	0.024	0.014	-	-	-	0.0022
Redear Sunfish	-	-	-	0.013	-	-	-	0.024	-	-	-	-	-	-	-	-	-	0.0021
Alligator Gar	-	-	-	-	-	-	-	-	-	-	-	-	-	0.029	-	-	-	0.0017
Bluegill x Warmouth hybrid	-	-	-	-	-	-	-	-	-	-	-	-	-	0.014	-	-	0.012	0.0015
Lake Chubsucker	-	0.013	0.012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0014
Mud Darter	-	-	-	-	-	-	0.013	-	-	-	-	-	-	-	-	-	0.012	0.0014
Green Sunfish x Bluegill hybrid	-	-	-	0.013	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0014
Pumpkinseed x Warmouth hybrid	-	-	-	0.013	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0008
Sauger	-	-	-	-	-	-	0.013	-	-	-	-	-	-	-	-	-	-	0.0008
Bluntnose Minnow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.012	-	-	0.0007
River Shiner	-	-	-	-	-	-	-	-	-	-	0.012	-	-	-	-	-	-	0.0007
Total	33.7	366	109	140	71.7	96.3	183	108	70.5	68.3	104	159	125	115	115	64.2	101	119

KEA 7: Fish Community Assemblages

Indicator: Number of native species populations

Desired Range: Native species ≥50% of number; Native species ≥50% of total biomass

Goal Met:

Met: 2007-2023

Not met:

Not measured:

Notes:

The abundance and biomass of native species were calculated from all gear types at random and fixed sites individually. Note that there were no fixed sites in 2007.

- The number of native fish species dominated the fish community in all years at random and fixed sites (Fig 13 and 14) and native fish biomass consistently remained above the desired range throughout all years (Fig 15 and 16).
- 2023 non-native biomass composition at fixed sites decreased to 12.8% (8 total non-native fish) in 2023 from 31.8% (14 total non-native fish) in 2022 (Fig 16).
- Non-native species consisted of common carp at random sites, and of common carp at fixed sites in 2023.
- Hybrid fish consisted of 3 bluegill x pumpkinseed and 1 bluegill x warmouth hybrids in 2023.
- Biomass of non-native fish has generally gradually increased over time. However, this biomass remains within the KEA parameters relative to native biomass, and was the lowest in 5 years in 2023 (lower value in 2017).
- Yellow bass abundance has increased since first detection in 2017. Despite lower abundances in 2022, yellow bass abundances rebounded in 2023. More information can be found in the Additional Analysis section.

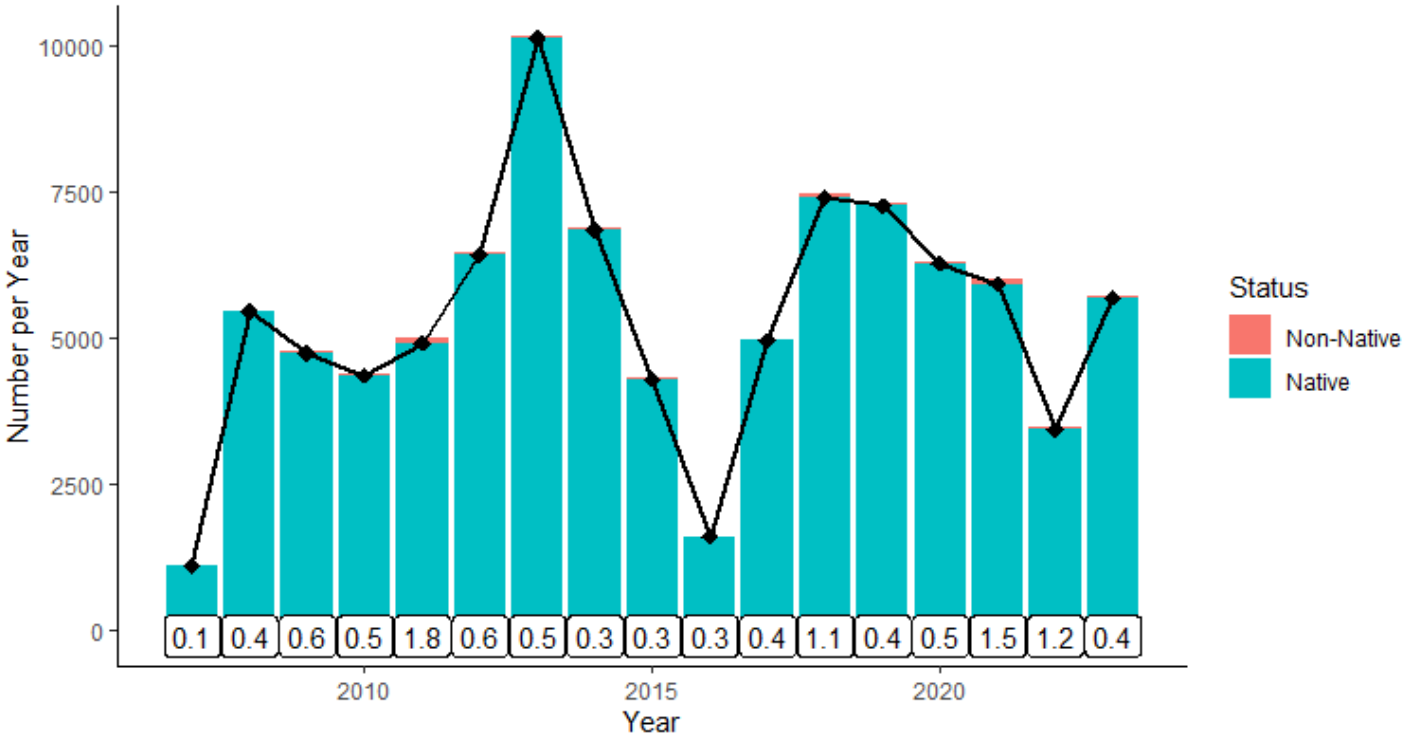

Figure 10. Total catch of fish per year by status collected at random sites at Emiquon from 2007-2023, with labels indicating the percentage of non-native fish.

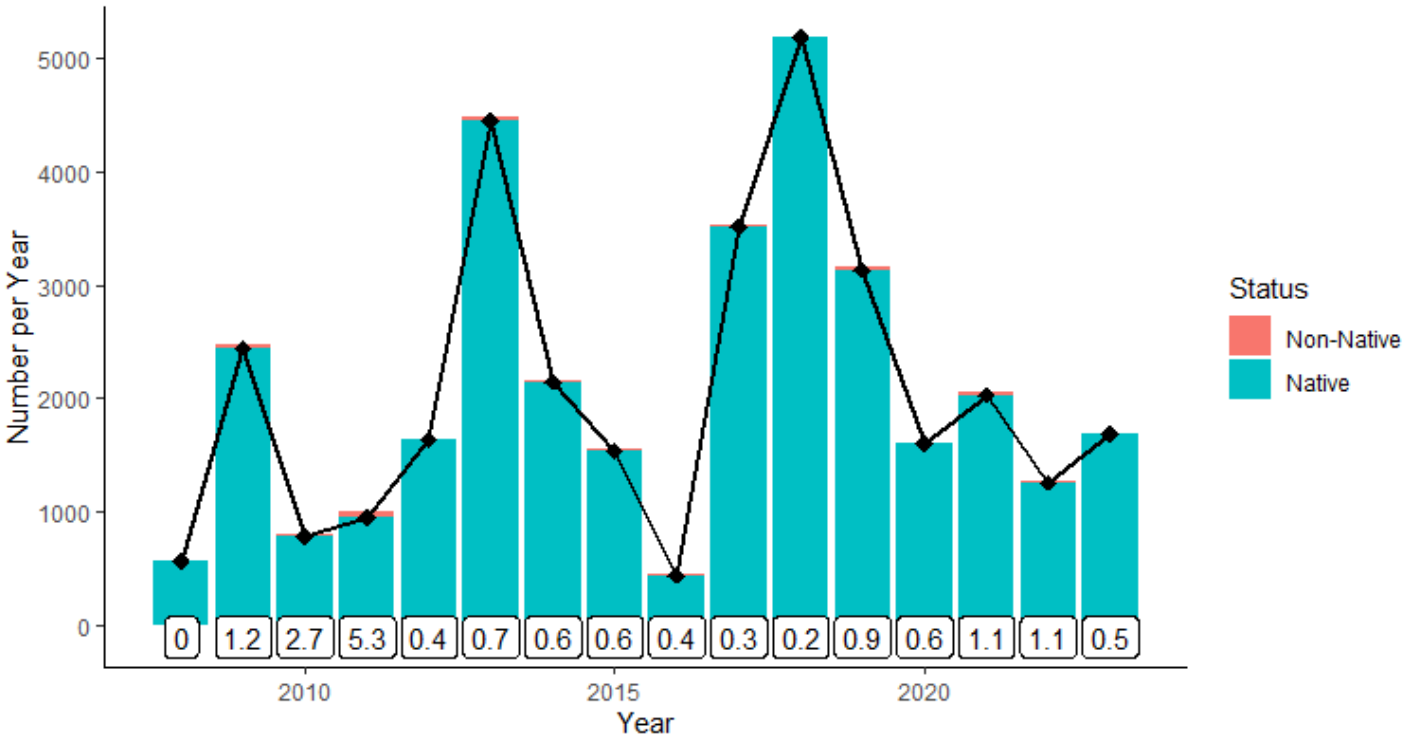

Figure 11. Total catch of fish per year by status collected at fixed sites at Emiquon from 2008-2023, with labels indicating the percentage of non-native fish.

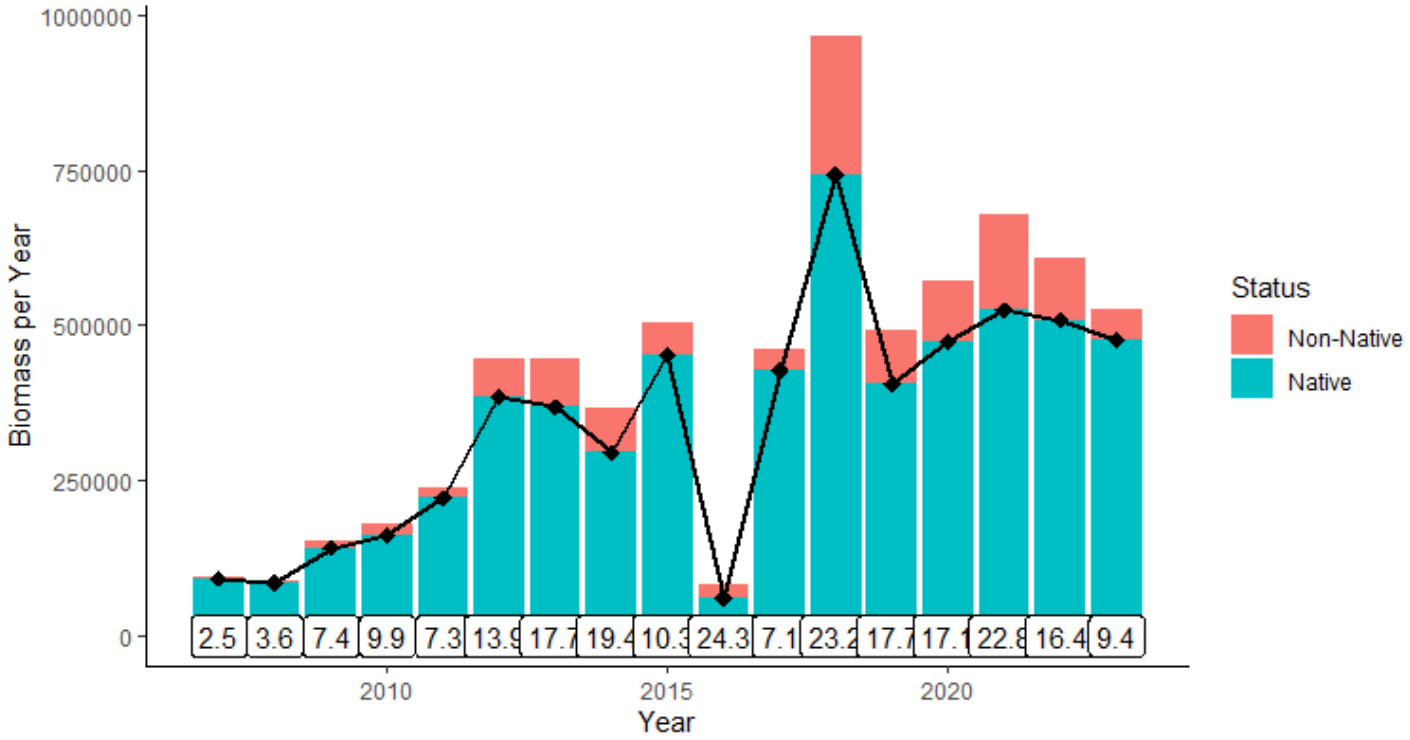

Figure 12. Total biomass of fish per year by status collected at random sites at Emiquon from 2007-2023, with labels indicating the percentage of non-native fish.

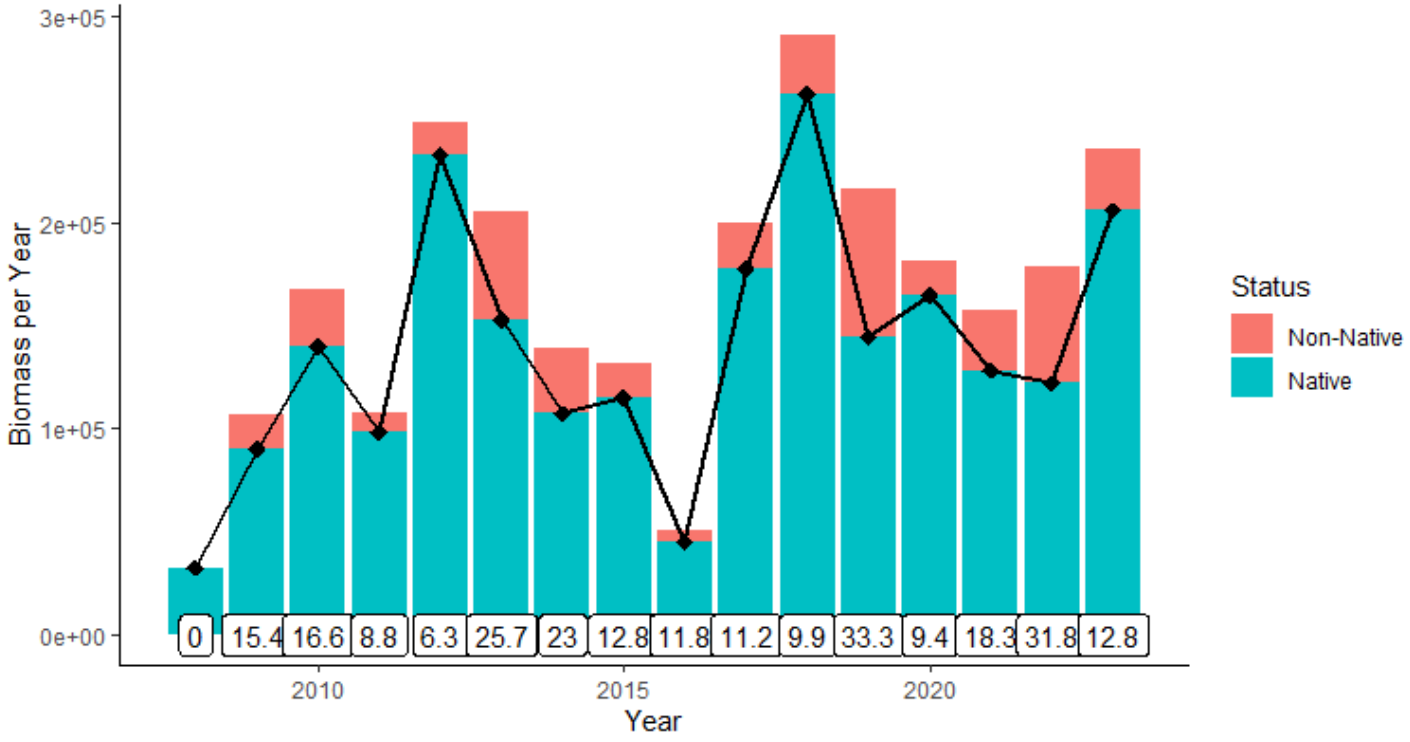

Figure 13. Total biomass of fish per year by status collected at fixed sites at Emiquon from 2008-2023, with labels indicating the percentage of non-native fish.

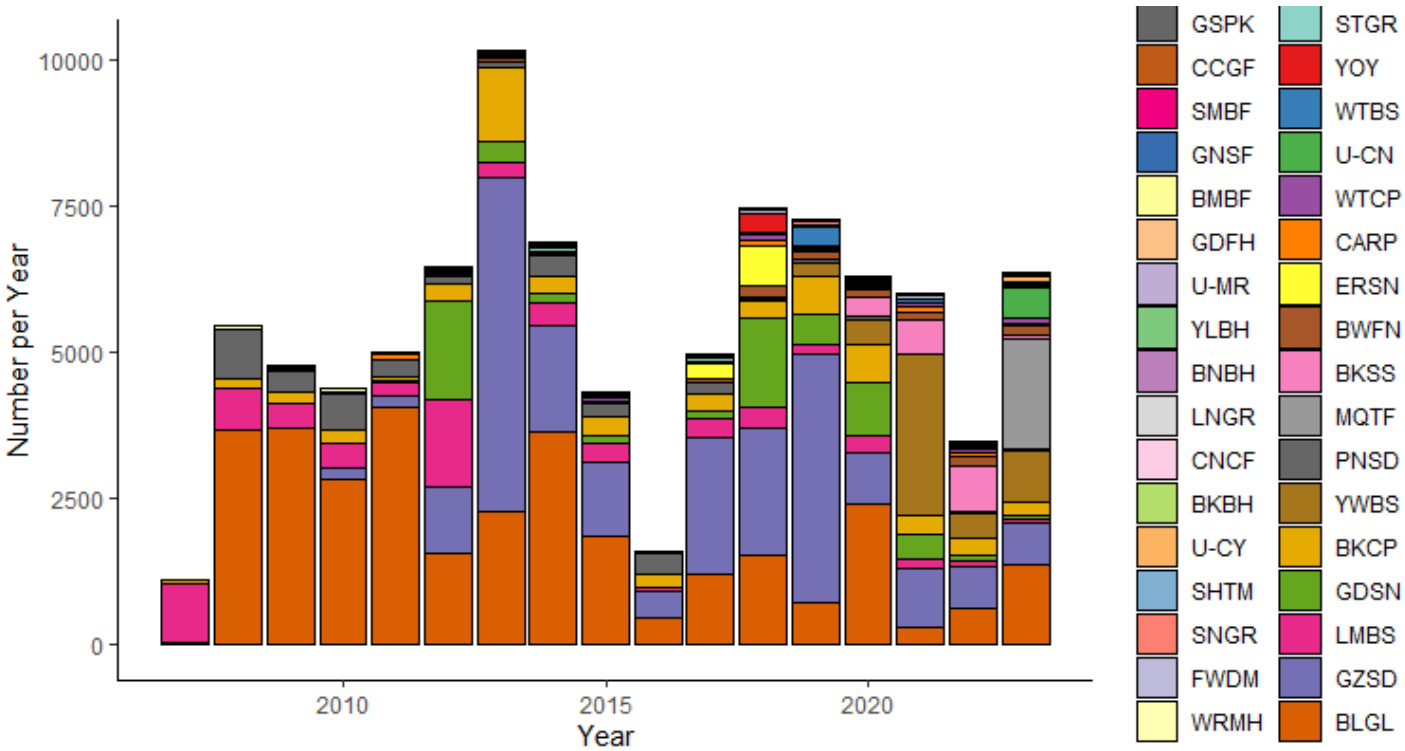

Figure 14. Total catch of fish per year by taxon collected at all D, F, and M sites at Emiquon from 2007-2023 for the 34 most-common taxa (leaving out the 6 least common).

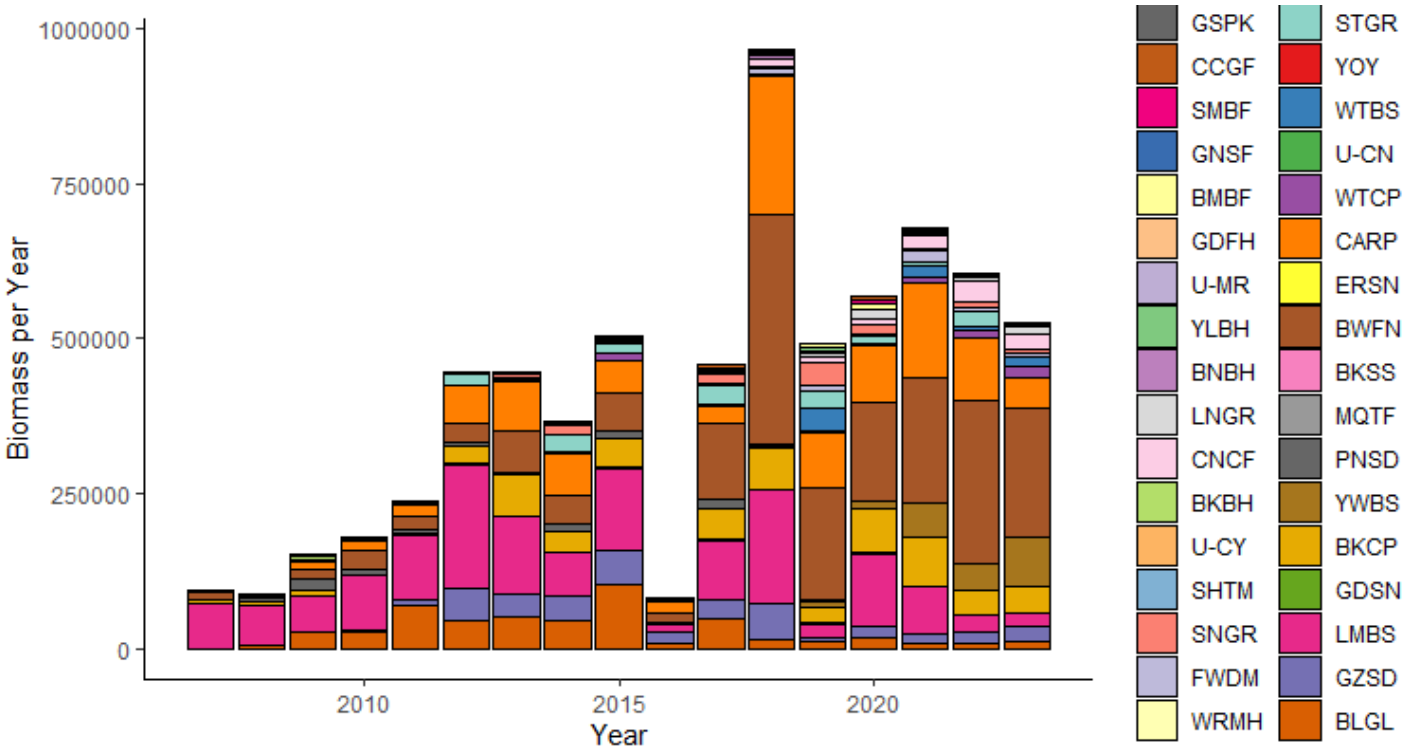

Figure 15. Total biomass of fish per year by taxon collected at all daytime electrofishing, fyke net, and minifyke net sites at Emiquon from 2007-2023 for the 34 most-common taxa (leaving out the 6 least common).

KEA 8: Fish Community Composition

Indicator: Body condition of native predatory fish population

Desired Range:

Very good = ≥100 largemouth bass (*Micropterus salmoides)* CPUE

*~ while electrofishing and bowfin (*Amia calva*) present ~ ,*

Good = 75-100 largemouth bass CPUE,

Fair = 50-75 largemouth bass CPUE,

Poor = <50 largemouth bass CPUE

Goal Met:

Very Good: 2007-2008.

Good: 2010, 2012.

Fair: 2009, 2013, 2015, 2020.

Poor: 2011, 2014, 2016-2019, 2021-2023.

Not measured:

Notes:

Largemouth bass CPUE was calculated using only day electrofishing and at random and fixed sites combined (Figure 17).

- Mean CPUE of largemouth bass decreased from 11.9 fish/hr in 2022 to 9.0 (SE: 2.0) fish/hr in 2023. This is the first time that largemouth bass CPUE in Emiquon is very similar to (i.e., not significantly different from) largemouth bass CPUE in the La Grange pool of the Illinois River (CPUE mean of 8.7 with a SE of 4.0 in 2023) (see Fig. 17). Emiquon preserve Emiquon largemouth bass CPUE historically was more similar to Pool 13 on the Mississippi River, which is considered a high-quality bass fishery (Fig. 17).
- The bowfin criteria, annual determination of presence or absence, was assessed from electrofishing data and species were present in all years.
- 181 Bowfin, 17 longnose gar (*Lepisosteus osseus),* 9 shortnose gar (*Lepisosteus platostomus), and* 3 spotted gar (*Lepisosterus oculantus)* were caught during regular 2023 sampling (Fig 18).

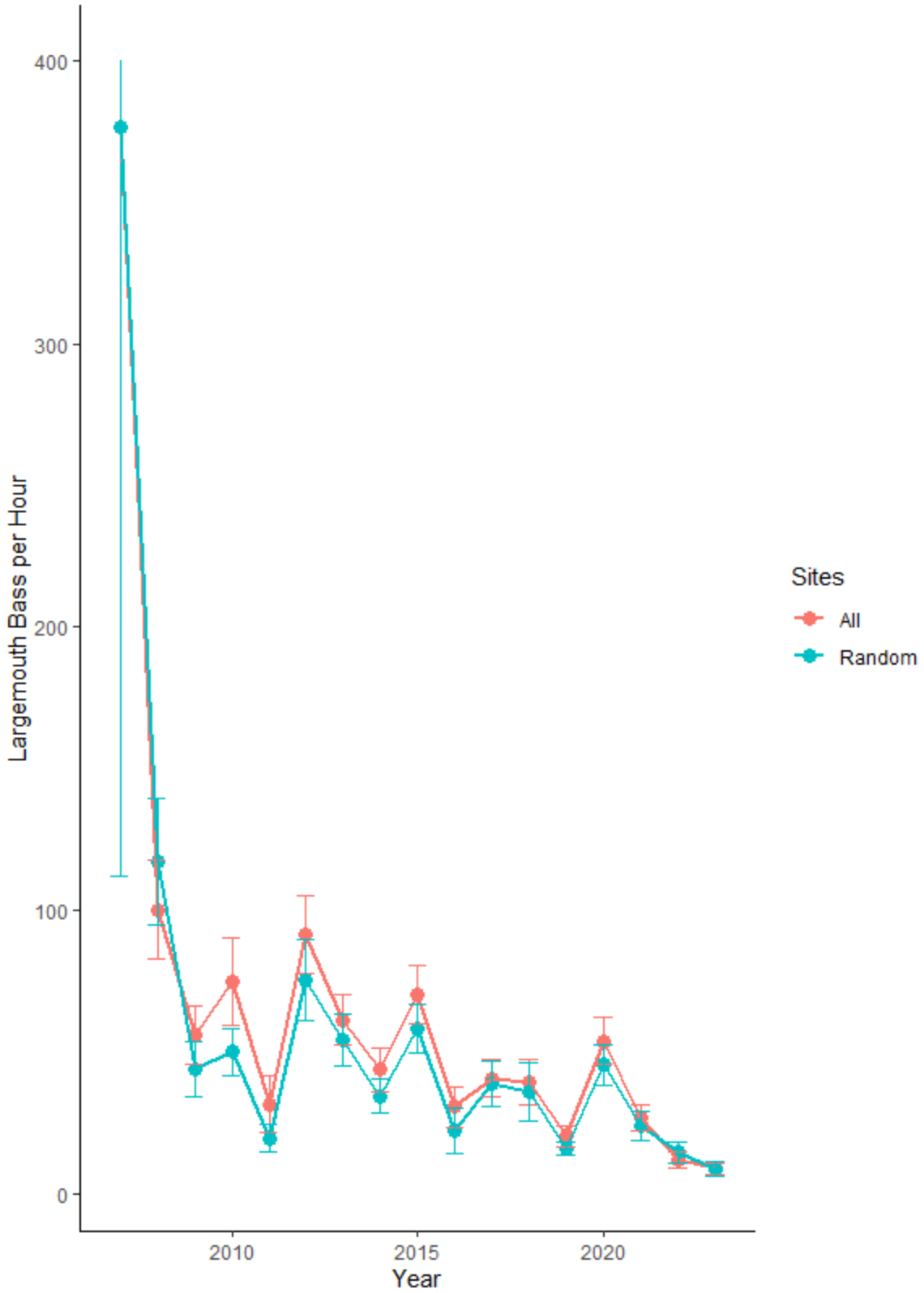

Figure 16. Largemouth bass annual mean abundance (CPUE-fish/hr) at random sites (Blue) and fixed and random sites (Red) from 2007-2023, follow a similar trend throughout the years.

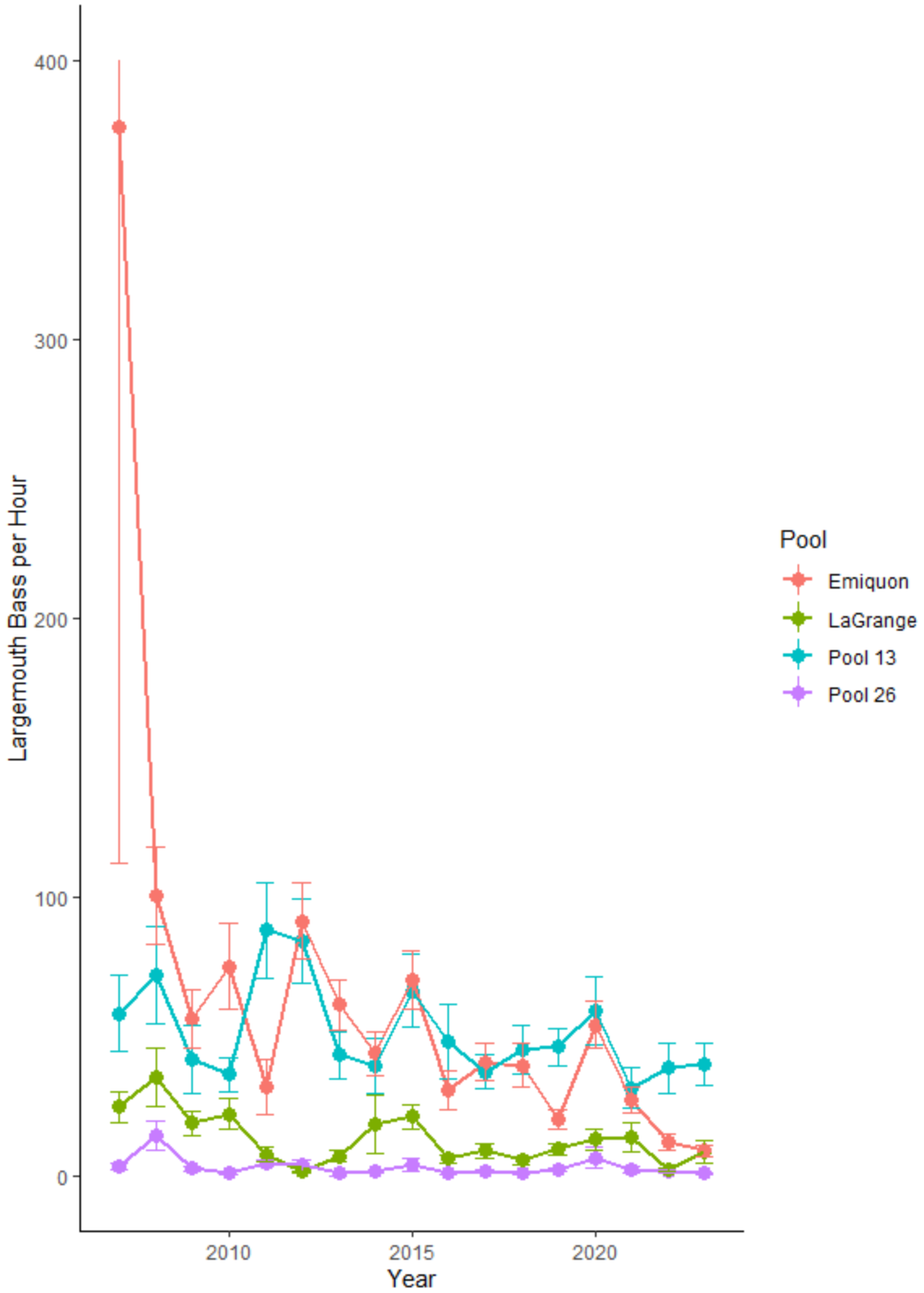

Figure 17. Comparison of largemouth bass CPUE (fish/hr) from Pools 13 (Blue) and 26 (Purple) on the Mississippi River, the La Grange pool of the Illinois River (Green), and the Emiquon Preserve (Red) from 2007-2023.

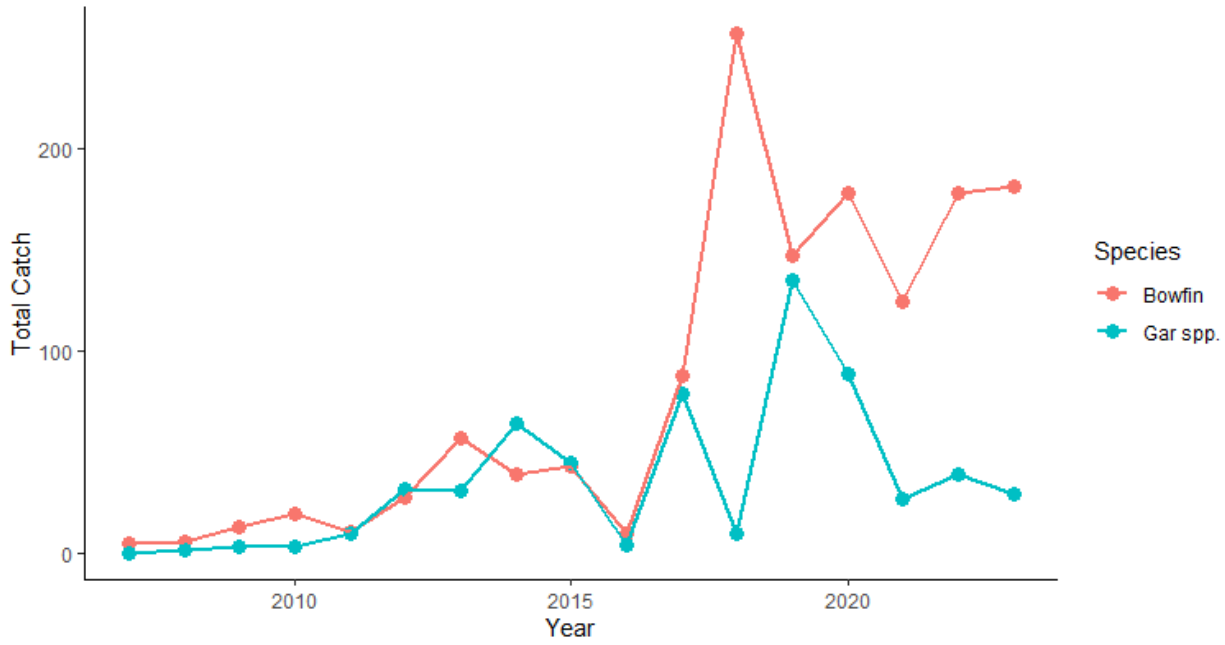

Figure 18. Bowfin have been present in all years 2007-2023, and gar have been present in all years 2008-2023. Gar species include spotted, shortnose, longnose, and alligator gar.

KEA 9: Spawning piscivores

Indicator: Water dissolved oxygen

Desired Range: 4 ppm oxygen (very good = ≥5 ppm and <200% saturation oxygen)

Goal Met:

Met: 2007-2023 (very good in all years)

Not met:

Not measured:

Notes:

Due to the lower number of vegetation sites in 2015-2023 when using box sampler methods, only fish sample sites were used to calculate the dissolved oxygen annual averages and plot those annual trends. DO values from fish data typically range early-mid April to mid-late October, except when sampling began late in some years (July start in 2007 (first year) and 2016 (staff change) and May start in 2020 (covid sampling restrictions)).

- Percent saturation was only recorded in the field during 2019-2023. Percent saturation values at fish monitoring sites during 2007-2018 were calculated for each sampling event with water temperature (°C) and oxygen concentration (ppm) values.

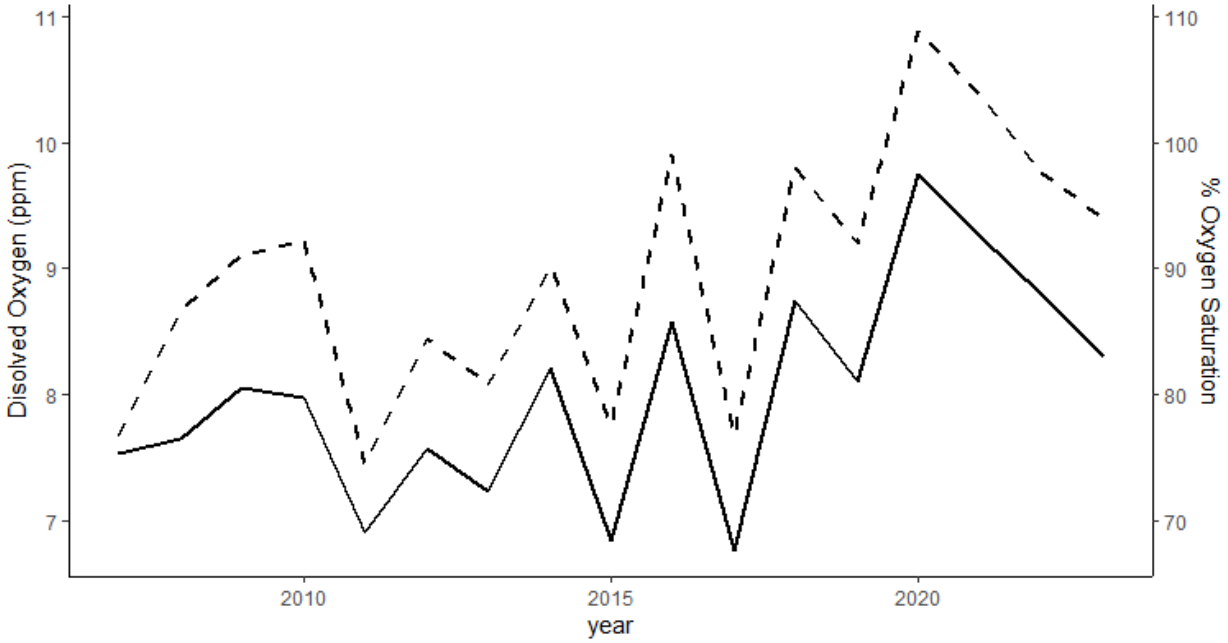

Figure 19. Annual mean dissolved oxygen concentrations (ppm, solid line) and percent oxygen saturation (dashed line) at all fish monitoring stations from 2007 to 2023.

Table 8. Annual, mean dissolved oxygen and percent saturation from 2016-2023, based on fish surveys conducted from April (sometimes July (2016 and 2007) or May (2020)) to October.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
DO (mg/L)	7.54	7.66	8.05	7.98	6.9	7.57	7.24	8.21	6.84	8.58	6.76	8.74	8.1	9.76	9.25	8.8	8.3
% Saturation	76.7	86.6	91.1	92.2	74.6	84.5	80.7	90.2	77.5	99	76.8	98	92	109	104	97.6	93.9

KEA 10: Spawning

Indicator: Substrate variability and structure (large woody debris)

Desired Range: Subset representing several of the following types present: diverse shoreline, shade, fallen trees, open areas, and submerged plants (very good = all types present)

Goal Met:

Met: 2007-2023

Not met:

Not measured:

Notes:

- Open areas are present in abundance.
- Shorelines are mostly shallow and sloping, with various substrates (sand, silt, hard concrete/gravel), but can be steep in ditch environments.
- Probably due to quickly-changing water levels and possibly to increased turbidity that may have resulted as well from drawdowns and droughts from 2018 to 2021, submerged aquatic plant beds were reduced in 2018 and 2020-2023 compared to 2009-2016 and 2019. Despite hydrology staying more consistent in 2022-2023 (as in 2019), aquatic vegetation has not substantially rebounded toward abundances observed in 2019 and prior to 2018. Current hypotheses posit lack of recovery to be due to both uprooting by common carp and also by high turbidity as driven by both high common carp abundances and also possibly by high wind fetch in the absence of SAV wind-breaks.
- We noted the presence of several aquatic plant beds (mostly floating and emergent and in ditches) along the shoreline, but minimal shading has been provided by woody debris.
- There was a notable brush pile of fresh leaves (seemingly due to muskrat activity) in the south ditch. This consistently held fish (abundant crappie, some largemouth bass, some bowfin, some bluegill, and the occasional unusual species like warmouth) when sampled.

KEA 11: Spawning

Indicator: Frequency of April/May connection to the river

Desired Range: Every three years for long-lived species, more frequently for short-lived species (very good = annual connection)

Goal Met:

Met:

Not met: 2007-2023

Not measured:

Notes:

- During 2023, no useable connection for riverine fishes to access Emiquon for spawning from the Illinois River occurred.

KEA 12: Nursery

Indicator: Accessibility for riverine fish

Desired Range: Presence of YOY freshwater drum, goldeye, and bigmouth buffalo. Very good would be the presence of all the above plus paddlefish.

Goal Met:

Met: 2018, 2020-2023.

Not met: 2007-2017, 2019

Not measured:

Notes:

Fish were considered YOY if they measured less than 100 mm TL. It should be noted that the Illinois River was disconnected from Emiquon until 2013 when the Illinois River overtopped the levee and inundated the Preserve. The species outlined in the desired range were not stocked and likely entered Emiquon during this flooding event since observations of the selected species were not seen until 2013 and beyond. Several other species were only detected after 2013, a likely result of the overtopping of the levee in 2013 (see Tables 6 and 7 above, and Table 9 below).

- Five YOY freshwater drum, zero YOY Catostomidae, and zero goldeye were collected during 2023 sampling.
- Zero Hiodontidae have been collected throughout the history of fish population monitoring at the Emiquon Preserve.
- While only 1 YOY bigmouth buffalo has been collected from the Emiquon preserve (in 2018), hundreds of YOY Catostomids (not identified to species) have been collected from 2013 – 2023 (mostly in 2018). That said, no YOY Catostomids were collected in 2023.
- In 2023, adult Catostomids collected included 3 bigmouth buffalo, and 1 smallmouth buffalo.
- Two to eight freshwater drum YOY have been collected from the Emiquon Preserve every year since 2018.

Table 9. Adult (≥ 100 mm TL) Freshwater Drum total catch by year since first caught in 2014.

2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1	1	0	20	50	23	21	36	32	32

KEA 13: Nursery

Indicator: Native fish larvae

Desired Range: Dominance of native species

Goal Met:

Met: 2007-2023

Not met:

Not measured:

Notes: All fish were considered YOY if they measured less than 100 mm in length.

- 5,399 native YOY fish were collected in 2023.
- During the 2023 sampling period, 1 YOY non-native common carp was collected during standard monitoring.
- Overall, the majority of YOY species collected in 2023 consisted of mosquitofish (35%), bluegill (26%), unidentified centrarchids (17%), gizzard shad (6.7%), yellow bass (5.3%), brook silversides (3.3%), unidentified cyprinids (1.7%), and golden shiners (1.5%).
- Native fish YOY have consistently out-numbered non-native YOY captures on average over the last 16 years (Fig. 20).

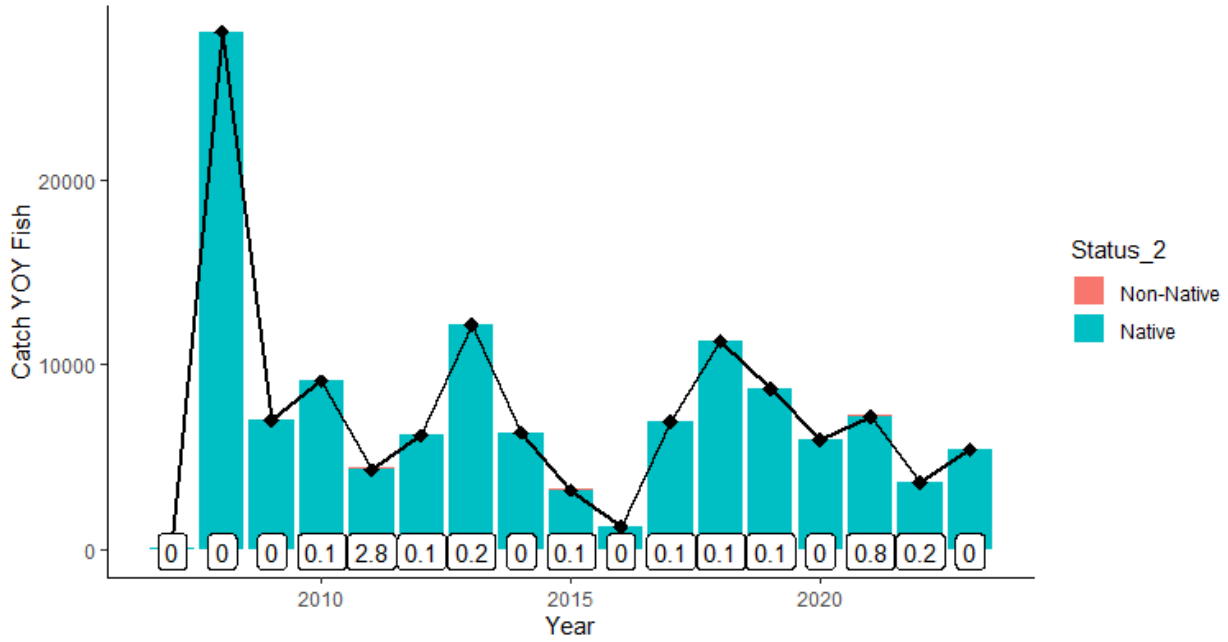

Figure 20. Annual total catch of YOY native and non-native fishes from 2007-2023, with labels indicating the percentage of non-native fish.

KEA 14: Feeding

Indicator: Presence of adults in good body condition

Desired Range: Mean relative weights 90-110

Goal Met:

Met or Exceeded: 2007-2023 for at least one species except as below:

Not met (too low): 2018 for Largemouth Bass

Not measured:

Notes:

Mean relative weight (W_r) for largemouth bass, bluegill, pumpkinseed, black crappie, were calculated following methods outlined in the third edition of Fisheries Techniques (Neumann et al. 2012). We used all individuals collected from daytime electrofishing or large fyke nets, unless they were below the minimum length threshold.

- In 2023, the relative weights of black crappie, bluegill, largemouth bass, and pumpkinseed all decreased from 2022.
- Only 1-2 weighable pumpkinseeds have been captured per year during 2021-2023 sampling, which is why error bars are so high in these years (Fig 22, Table 10).
- Mean relative weight for largemouth bass, black crappie, and bluegill started high after initial restoration and declined over the past 10 years, after which time their relative weights have remained relatively stable (Fig 22, Table 10).

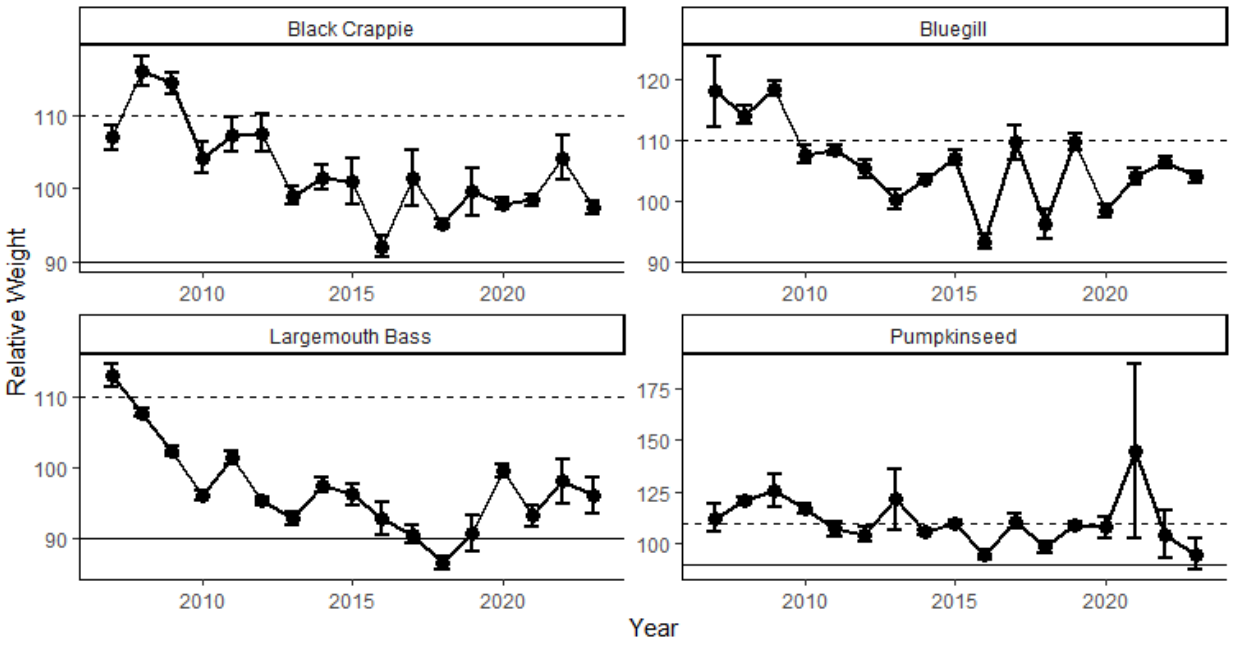

Figure 21. Annual mean relative weight (Wr) of black crappie, bluegill, largemouth bass, and pumpkinseed from 2007 to 2023 from random and fixed electrofishing and large fyke net samples. Minimum lengths of fishes included in relative weight calculations are 100 mm for black crappie, 80 mm for bluegill, 150 mm for largemouth bass, and 50 mm for pumpkinseed.

Table 10. Annual relative weight means and standard errors (in parentheses) of four centrarchids at the Emiquon Preserve.

Year	Black Crappie	Bluegill	Largemouth Bass	Pumpkinseed
2007	107 (1.7)	118 (5.8)	113 (1.6)	112 (6.8)
2008	116 (2.1)	114 (1.5)	108 (0.54)	121 (1.5)
2009	114 (1.4)	119 (1.2)	102 (0.73)	125 (8)
2010	104 (2.1)	108 (1.5)	96.1 (0.69)	117 (2.5)
2011	107 (2.4)	108 (0.9)	101 (0.97)	107 (3.4)
2012	108 (2.6)	105 (1.5)	95.3 (0.49)	105 (3.4)
2013	99.1 (1.1)	100 (1.7)	92.9 (0.89)	122 (15)
2014	102 (1.8)	104 (0.72)	97.5 (1.1)	105 (1)
2015	101 (3.2)	107 (1.3)	96.3 (1.5)	110 (1.5)
2016	92 (1.5)	93.3 (1.3)	92.9 (2.3)	94.8 (2.4)
2017	101 (3.9)	110 (2.9)	90.7 (1.3)	111 (3.5)
2018	95.2 (0.55)	96.2 (2.4)	86.7 (0.91)	98.3 (2.5)
2019	99.6 (3.3)	110 (1.4)	90.8 (2.5)	109 (1.5)
2020	97.9 (0.8)	98.3 (0.96)	99.5 (0.88)	108 (5)
2021	98.4 (0.8)	104 (1.5)	93.3 (1.6)	145 (42)
2022	104 (3.0)	106 (0.95)	98.1 (3.1)	104 (12)
2023	97.3 (0.87)	104 (0.92)	96.1 (2.5)	95.0 (7.3)

KEA 15: Feeding

Indicator: Distribution of abundant aquatic vegetation

Desired Range: 25-40% of the littoral area contains abundant vegetation during July-August.

Goal Met:

Met or Exceeded: 2008-2023

Not met (too low):

Not measured: 2007

Notes:

- Presence of vegetation at littoral sites was lower during drawdown years 2018, 2020, and 2021 (but still met KEA goal). Vegetation did not rebound in 2022 and 2023 to levels seen in earlier non-drawdown years, despite lack of drawdown (and non-drought conditions).
- Aquatic vegetation presence in littoral areas has remained above the desired range of 25-40% at fish sampling locations in all years, with the exception of the first year of flooding in 2007, when vegetation presence was not measured (Fig 23).

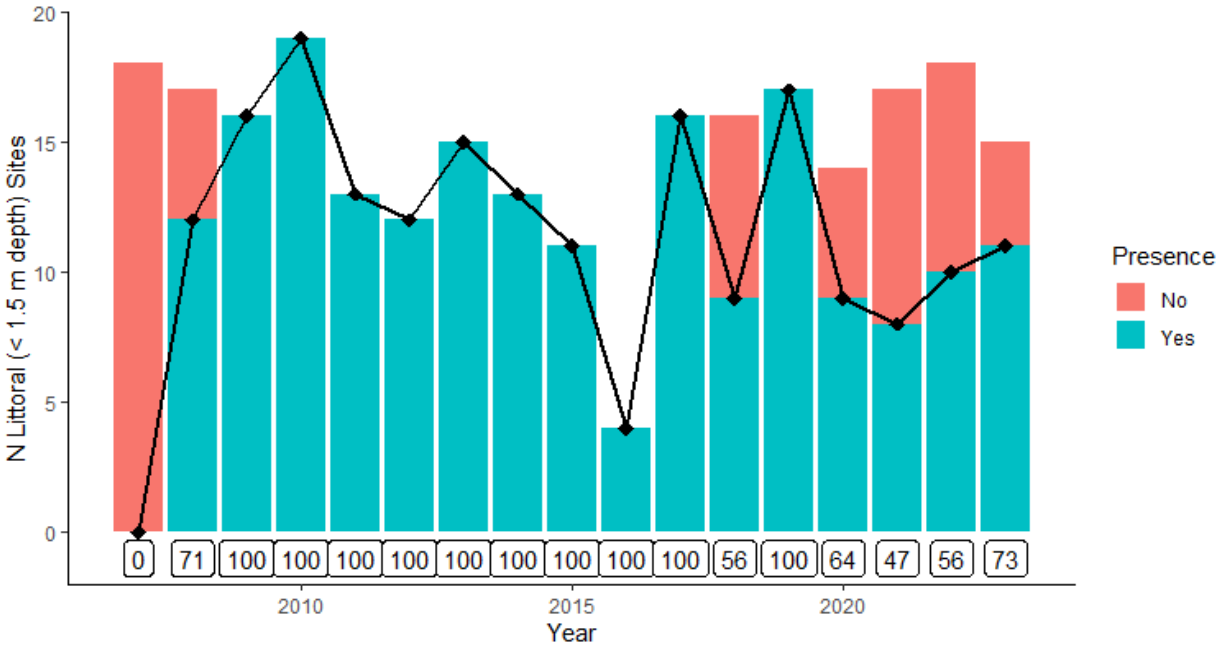

Figure 22. Number of sites with or without vegetation present from 2008-2023. Percentage of vegetation present (label below each year's bar) exceeds the desired goal in all years since 2008, thus providing shading and habitat for fish.

KEA 16: Over-wintering

Indicator: Percent of deep (oxygen rich) water

Desired Range: Water depth (5% >3 m, 10% 2-3 m, 25% 1-2 m, 60% <1 m); Dissolved oxygen (4.0-6.0 ppm at 2 m depth).

Goal Met:

Met: 2011, 2013- 2015, 2018, and 2022

Not met: 2020

Not measured: 2007-2010, 2012, 2016, 2017, 2019, 2021, and 2023

Notes:

Percent of deep water at Thompson and Flag lakes were calculated using bathymetry mapping in 2011 and 2013-2015. Dissolved oxygen concentrations were also recorded during these years at fixed site locations. Sampling was not conducted from 2007-2010, 2012, 2016-2017, 2019, and 2021.

- Sampling for winter of 2023-2024 was abandoned because of consistently good metrics throughout all years when measured, and because of a very brief ice season in the winter of 2023-2024.
- The persistence of high numbers of native fish species across years provides indirect evidence that fish have been over-wintering successfully at Emiquon.

KEA 17: Over-wintering

Indicator: Presence of backwater species

Desired Range: Water temperature ≥1 °C (34 °F) at 2 m depth based on the needs of freshwater drum (Bodensteiner & Lewis 1992)

Goal Met:

Met: 2013, 2014, 2015, 2018, and 2022

Not met: 2020

Not measured: 2007-2012, 2016, 2017, 2019, 2021, and 2023

Notes:

This KEA was added in 2013 and is based on temperature readings at fixed site locations from 2013-2015 during ice-on conditions.

- Sampling for winter of 2023-2024 was abandoned because of consistently good metrics throughout all years when measured, and because of a very brief ice season in the winter of 2023-2024.

KEA 18: Over-wintering

Indicator: Concentrations of over-wintering native species

Desired Range: Maximum electrofishing CPUE (hot spots) for wintering native species exclusive of gizzard shad and minnows >1500 individuals/hr and >5 species (very good = >2000/hr)

Goal Met:

Met:

Not Met: 2013, 2015, and 2018

Not measured: 2007-2012, 2014, 2016-2017, 2019-2023

Notes:

- Winter electrofishing was not conducted in 2011-2012, 2014, 2016-2017, and 2019-2023.
- In 2019, after discussions about the relevance of this KEA was discussed by Dr. Jim Lamer, Director of the Illinois River Biological Station, and Doug Blodgett, the Director River Conservation at the Nature Conservancy at Emiquon, it was decided this KEA will no longer be measured.

KEA 19: Feeding

Indicator: Secondary production delivered to the river

Desired Range: Loading and timing of plankton, macroinvertebrates, and fish delivered to the river.

Goal Met:

Met:

Not met:

Not measured: 2007-2023

Note:

- The Nature Conservancy conducted a drawdown in 2021 decreasing the water surface level to 427.98 ft. Although secondary production delivered to the Illinois River has never been quantified, it likely occurred during drawdown periods when water was released through the water management structure.
- A study by Kara Phelps, a former graduate student at the University of Illinois-Springfield, has preliminary data evaluating whether Emiquon water may have contributed zooplankton to the Illinois River during a drawdown pumping event (Phelps et al., 2023).

Publications and Presentations

Holda, T., J. Lamer, A. Gilbert, and A. Blackert. 2023. Submerged vegetation at the Emiquon Preserve. Oral Presentation. Emiquon Science Symposium.

Additional (Non-Monitoring) Projects

Baseline herpetofauna study at two wetland preserves: multiple gear approach using six survey techniques to determine occupancy and abundance of herpetofauna at Emiquon and Merwin preserves. Field work last concluded in September 2019 – analysis and interpretation of data is still ongoing.

Invasive carp removal: collection of bigheaded carp (silver and bighead carp) to analyze otoliths using microchemistry to determine natal origin and post clethra for aging occurred in late 2018 using trammel nets, and electrofishing. Western Illinois University students used gill nets to target silver carp for Chelsea Center's graduate project. In October 2019, IRBS staff used trammel nets to capture Asian carp and mark them either with a jaw tag (bigheaded carp) or removal of the left pectoral fin (common and grass carp), these fish were then released. In 2020, pectoral spines were taken from bigheaded carp as a continuation of the aging project beginning in 2018. There are no plans for additional data collection at this time. Data analysis is planned, and a report or publication is to be pursued in the future.

Commercial fishing in Emiquon: The Nature Conservancy is allowing commercial fisherman to fish Emiquon for targeted removal. By the end of December, 2023, 7,098 silver carp (59.6 tons), 3,733 common carp (22.3 tons), 671 grass carp (5.1 tons), and 287 bighead carp (4.2 tons) had been removed, with only 10 tagged individuals recovered (9 tagged silver carp, and 1 tagged bighead carp – most recently in 2021). Removal has continued into 2024. Additional data (lengths and weights of captured fish, and some silver carp spines) were taken for one event in early 2023.

Sportfish vital rates: Largemouth bass, black crappie, and bluegill were collected in Spring of 2021 (April - May) to extract otoliths. Approximately 736 fish were collected for this project for both years. Analysis of these data are of lower priority than other projects related to invasive species in Emiquon, but a publication is intended to be pursued at some point in the future.

Evaluation of Asian carp use of a steeppass fish ladder: In collaboration with ILDNR, TNC, and Whooshh Innovations, a steeppass fish ladder was installed at the Emiquon water control structure, on the river side of the levee. During a five-day trial in September 2020, water was pumped from Emiquon and flowed down the steeppass to attract fish to the area. Additional

trials were conducted in the spring of 2021. In the second set of collections, the Wi-Fi cameras were replaced with an AI camera system developed by Whoosh Innovations. Other changes were made to the system based on observations from the 2020 trial, including lifting the ladder and adding a net to the opening of the out flow false weir for easier fish collection. Water quality parameters were measured before, during, and after steeppass operation, including dissolved oxygen, temperature, conductivity, chlorophyll-a, and turbidity. In addition, zooplankton samples were collected daily during the same time period. At the end of the collections, we ran 6 trials of different lengths of time, and had 1807 fish (8 species) moved through the fish steeppass and one snake. Plans began in 2022 to put the steeppass fish ladder on a floating barge so that the system could operate in a wider range of water levels on the Illinois River. This barge system was put in place in July of 2023. Numerous tests have not yet been able to attract fish to the steeppass system. It is possible that waterflow out from Emiquon during drawdowns is what constituted the primary attraction for riverine fish species to the steeppass ladder.

Additional Analysis

Other bass species in Emiquon: Yellow bass were first recorded during general monitoring in 2017 when two individuals were captured. Since the initial capture, the number of individuals caught each year has increased. In 2023, 1406 individuals were captured during general monitoring, including adults and young of year individuals. Sizes ranged from 20-404 mm in length. Multiple individuals have been captured and morphologically identified as yellow bass x white bass hybrids in 2023. White bass were first captured in the Emiquon preserve in 2018, when 22 individuals were captured. Forty-six white bass were captured in 2023, with total lengths ranging 20-471 mm.

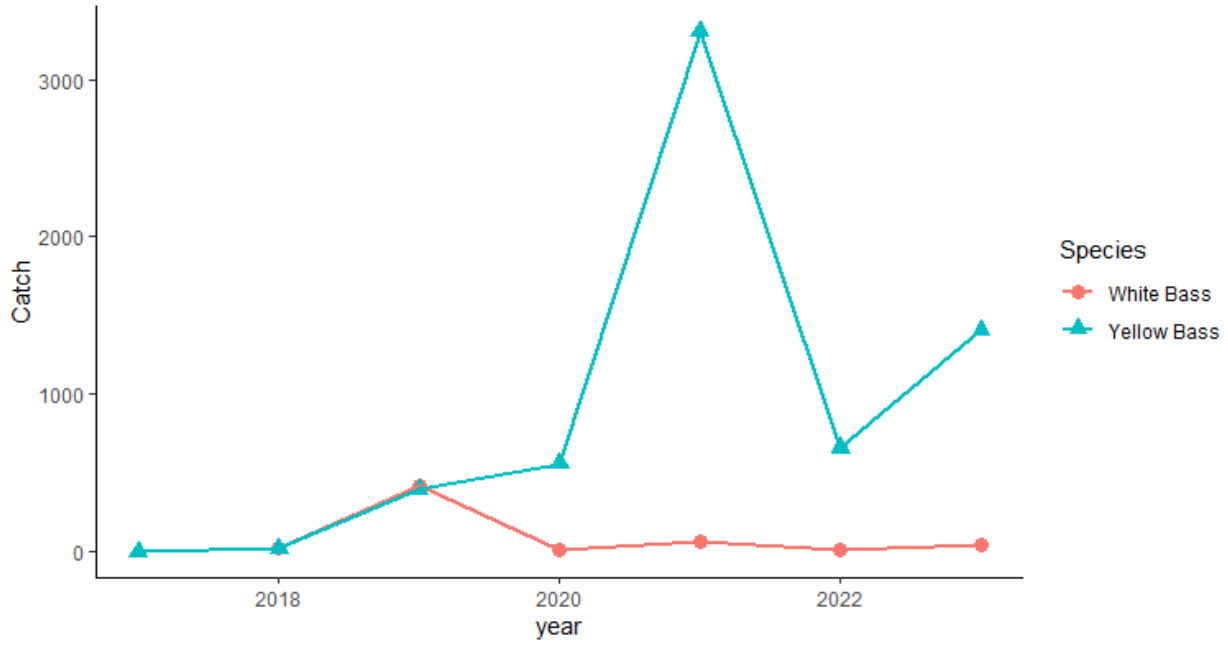

Figure 23: Number of yellow bass (blue line) and white bass (red line) captured from 2017-2023 in Emiquon.

A comparison of Emiquon and the LaGrange backwaters: At the request of TNC staff, we have included additional information that helps offer context to data collected within Emiquon. Below are length frequency graphs of largemouth bass, black crappie and bluegill collected in annual monitoring from Emiquon and from the Upper Mississippi River Restoration Program's Long-Term Resource monitoring (LTRM) efforts on the adjacent La Grange pool backwater areas. Note the differing y-axis on each graph from year to year and site to site. Also note these are not meant to illustrate abundance of any of the species below but are meant to represent size structure of fishes sampled in each system.

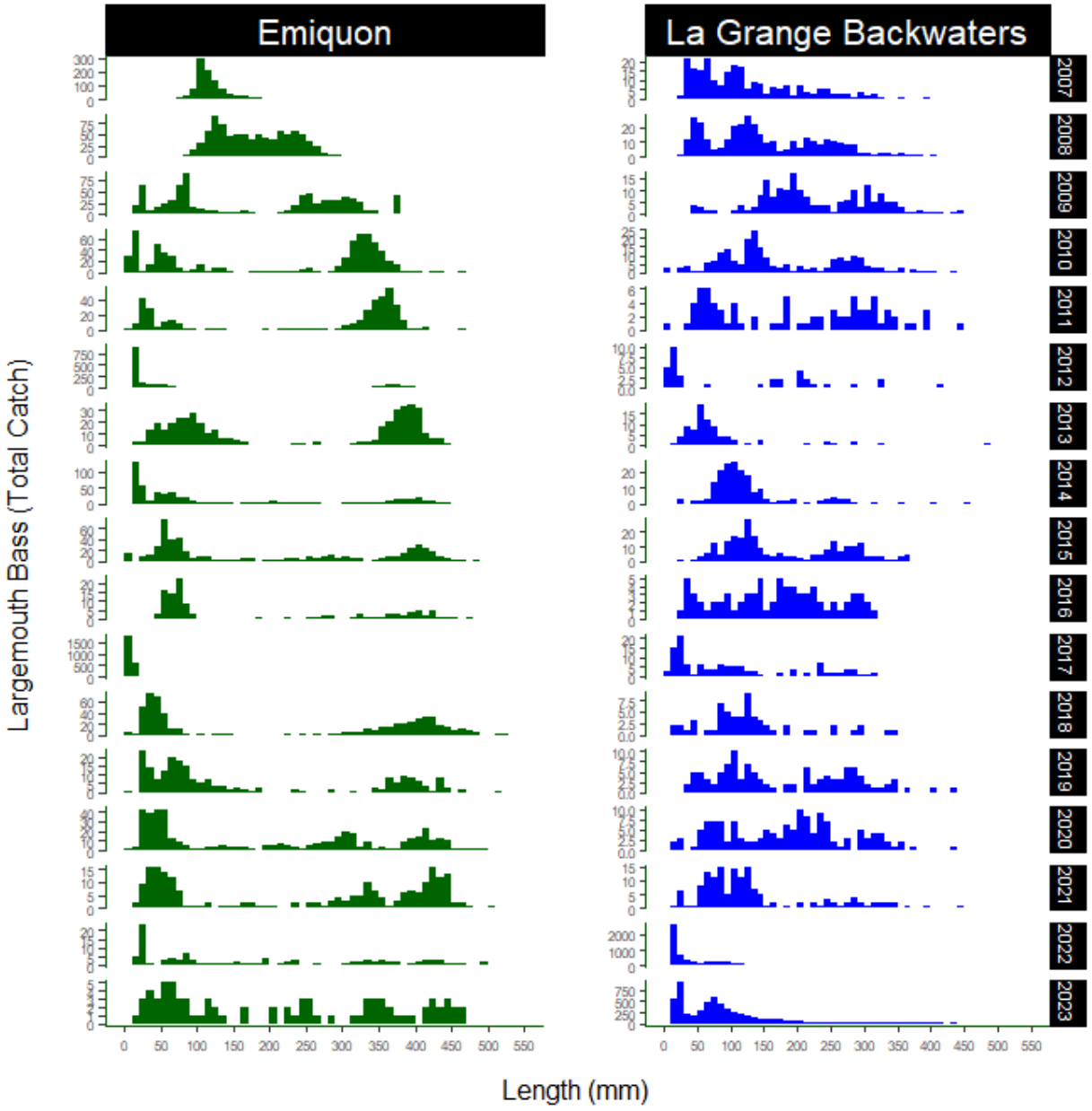

Figure 24: Comparison of largemouth bass size structure between Emiquon and LaGrange backwaters from 2007-2023. Numbers of individuals vary with each year according to catch frequency differences between Emiquon and La Grange backwaters.

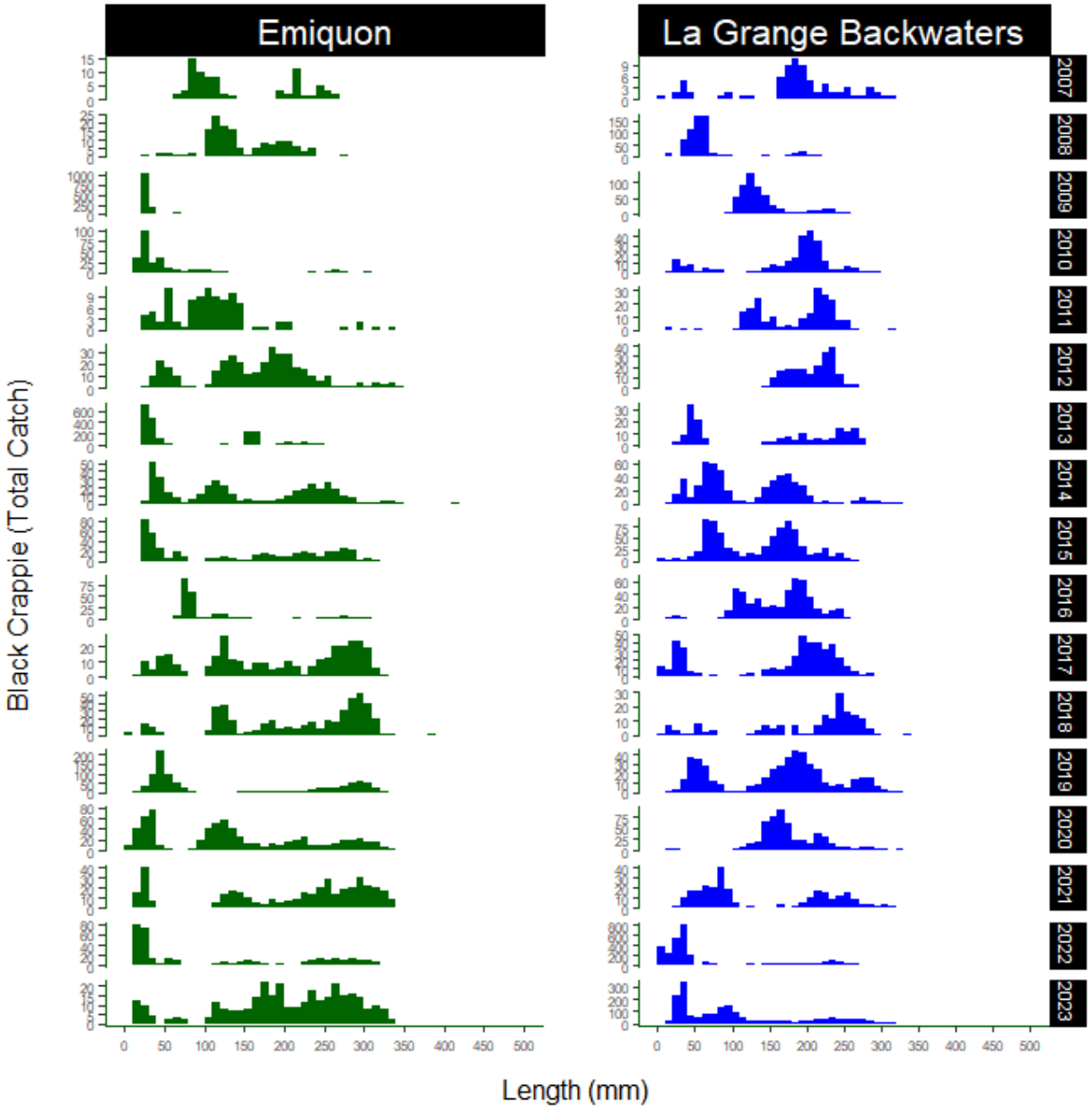

Figure 25: Comparison of black crappie size structure between Emiquon and La Grange backwaters from 2007-2023. Numbers of individuals vary with each year according to catch frequency differences between Emiquon and La Grange backwaters.

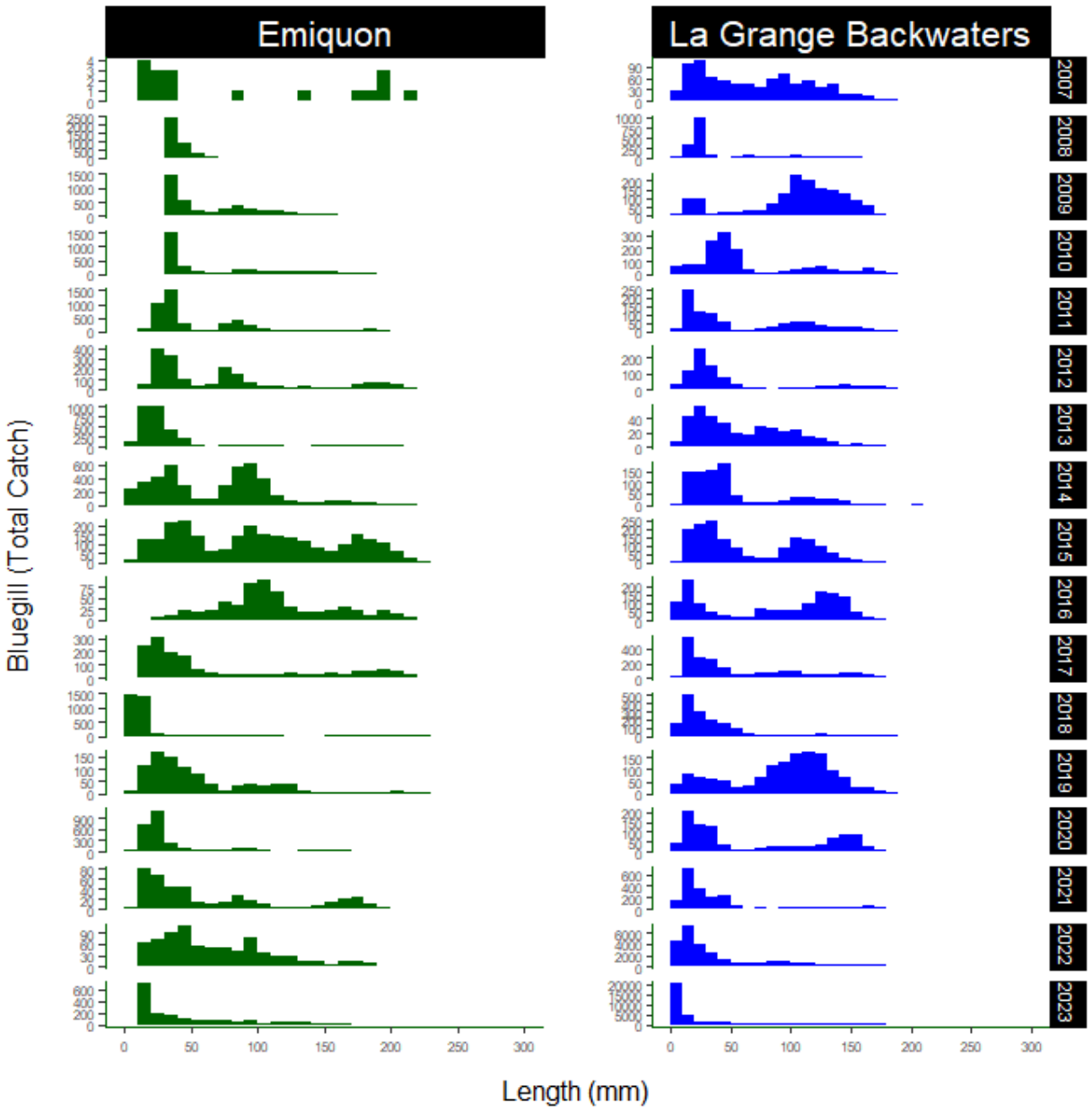

Figure 26: Comparison of bluegill size structure between Emiquon and La Grange backwaters from 2007-2023. Numbers of individuals vary with each year according to catch frequency differences between Emiquon and La Grange backwaters.

Common Carp Catches per Sampling Event: Common carp have gradually increased in abundance at the Emiquon Preserve and may be a cause of reduced submerged aquatic vegetation at the Emiquon Preserve in recent years. Below is a simple graph of catch per sampling event over time by gear. Note that there was a high occurrence of small common carp in minifyke nets in 2011. The increase in abundance and biomass in 2013 may have been due to levee overtopping during that year, or perhaps due to survival and growth of that cohort. As to higher values observed in 2018 and 2020-2023, it may be that lower water levels in those years are partly responsible for the high catch rates in those years.

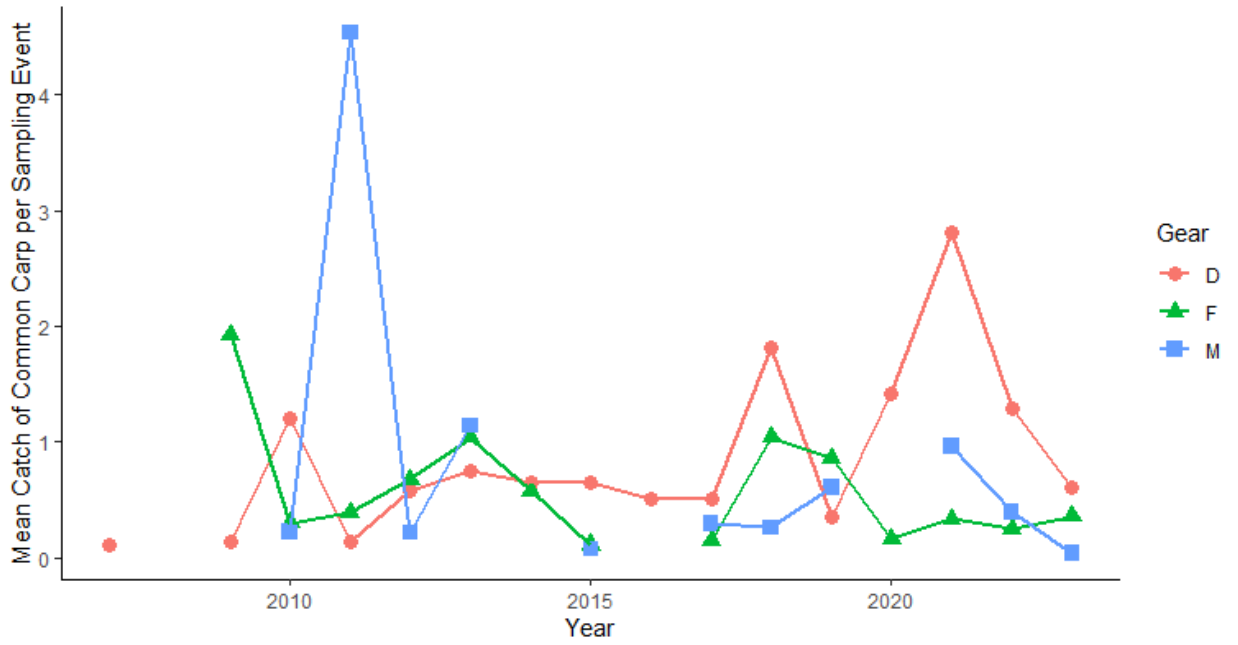

Figure 27: Catch per sampling event by gear (15-minute electrofishing run: D, large fyke net: F, or minifyke net: M) of common carp in the Emiquon Preserve during monthly fisheries community monitoring from 2007-2023. Common carp have increased in abundance in the Emiquon Preserve over time.

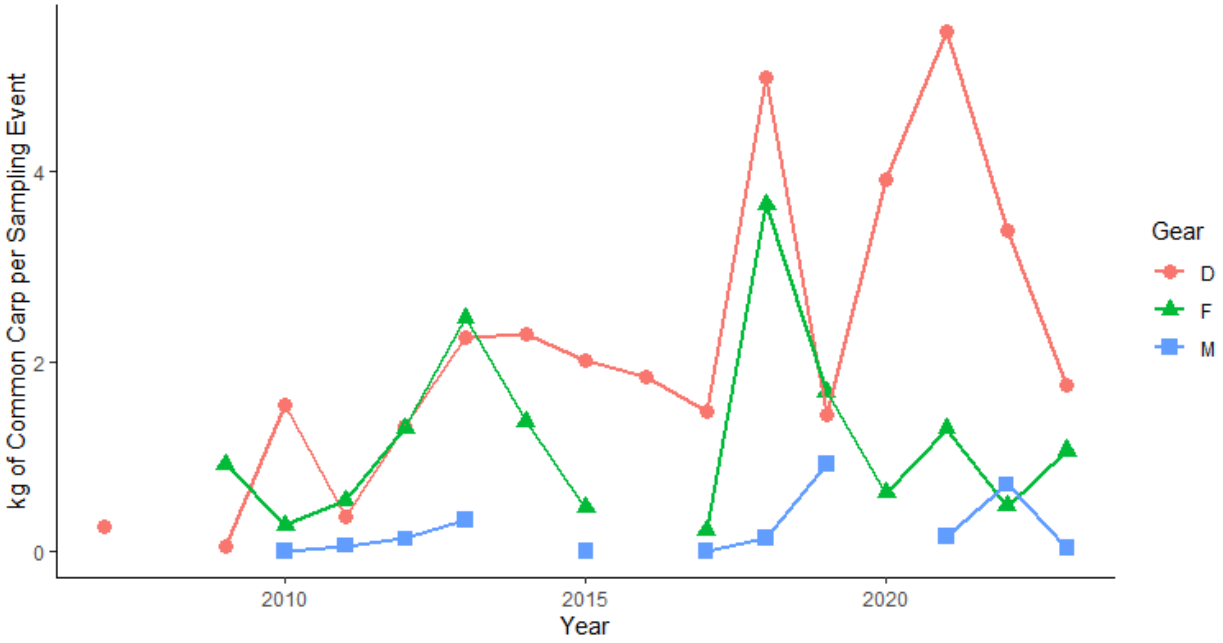

Figure 28: Biomass (kg) per sampling event by gear (15-minute electrofishing run: D, large fyke net: F, or minifyke net: M) of common carp in the Emiquon Preserve during monthly fisheries community monitoring from 2007-2023. Common carp biomass has substantially increased in the Emiquon Preserve over time.

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