Fish Community Response to Wetland Connectivity Enhancement at the Lakeview Marsh Wildlife Management Area

Final Report

GLC-3874 Lakeview Marsh Restoration Project

ESF Sub Agreement

Submitted to:

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Executive Summary

Short-term evaluations of the abiotic environment and fish community response to the wetland enhancements at the Lakeview Marshes WMA indicate positive responses and high use by a diverse array of fishes. Modified habitats (spawning pools) showed a general indication of higher dissolved oxygen levels. Fish use as indicated by catch during emigration was high for modified habitats at a statistically discernible level in 2023 and was comparable to natural functioning reference sites. The catch of over 43,000 young of year and older fish is an indicator of the importance of Great Lakes wetlands as a critical habitat for fish reproduction. Notably, nearly all the catch was composed of native species, and no recent invaders were detected despite their dominance in Lake Ontario. Fish are dependent on a complex community of aquatic species and their ability to reproduce and grow in the created habitats is an indicator of significant ecological function.

Background

The Lakeview Wildlife Management Area (WMA) received channel and pothole wetland enhancements in response to habitat degradation associated with invasion and dominance of hybrid cattail (Typha x glauca) and other invasive plants. ESF received a subcontract to assess the response of the modifications to the fish community and the abiotic environment in the form of water temperature and dissolved oxygen levels. Coastal wetlands in the Laurentian Great lakes provide critical spawning and nursery habitat for fish with 113 species documented in Great Lakes wetlands (Jude & Pappas, 1992). Coastal wetlands, especially in Lake Ontario and the Upper St. Lawrence River are degraded by invasive hybrid cattail dominance and its detrimental effects to rapid wetland accretion (Rippke et al. 2010), loss of connectivity (Farrell et al., 2010), and impact on aquatic abiotic conditions (Schrank & Lishawa, 2019). Enhancement plans for Lakeview WMA were expected to improve wetland connectivity may also but were expected to influence abiotic conditions like water temperature and dissolved oxygen (DO) further enhancing aquatic habitat. Similar enhancements in the upper St. Lawrence River in drowned river mouth wetlands and in protected bays received potholing and connectivity modifications and showed significant fish use and habitat changes (Neveldine et al. 2019; Leblanc and Farrell, 2023). Lakeview Marsh WMA, however, exists in a different geomorphic setting (barrier wetland) and is in the Lake Ontario ecosystem. A one-season baseline understanding of current abiotic conditions and fish assemblages was developed for Lakeview WMA by comparing unaltered reference sites to degraded channels prior to enhancements in 2023. Effective pre- and post-restoration surveys helped gauge restoration success and further our understanding of effective Great Lakes coastal wetland restoration.

Year-one (Y1) fish and older potadromous fishes migrate and occupy coastal wetlands like Lakeview WMA as habitats for spawning and their progeny use these areas for early development during a nursery period (Jude & Pappas, 1992). Both Y1 and young-of-year (YOY) fishes typically migrate from these habitats during development when they grow larger but also when conditions become intolerable such as low water level, increased water

temperatures, and low dissolved oxygen (DO) (Junk et al., 1989; Leblanc & Farrell, 2023). Less sensitive resident species that are low oxygen tolerant may remain and possess specialized respiratory adaptations to exist in hypoxic environments. Young-of-year fish emigration is often identified as an important milestone in their early life history and can set up potential for strong year class formation that supports the adult population and their ecological services and fisheries. Common native species of recreational importance such as Northern Pike (*Esox lucius*), Yellow Perch (*Perca flavescens*), and Largemouth Bass (*Micropterus salmoides*) utilize spawning pool habitats like Lakeview WMA. In addition, these habitats provide shelter for multiple native species in families such as Darters (*Etheostoma*) and Minnows (*Cyprinidae, Leuciscidae*). The NYS Department of Environmental Conservation identifies Western Pirate Perch (*Aphredoderus sayanus*), and Blackchin shiner (*Notropis heterodon)* in Lakeview WMA (Mazzocchi et al., 2018; Lisa Holst, Rare Fish Unit Leader, Bureau of Fisheries) as species of greatest conservation need, further signifying its importance for Lake Ontario fishes. Our overarching objectives were to assess the water conditions and evaluate the fish community associated with the newly constructed aquatic habitats and compare them to existing reference habitats.

Objective

1. Compare water temperature, dissolved oxygen and fish catch data from pre- and post-restorations completed in spawning pools in 2024.
2. Evaluate modified spawning pools in comparison to reference habitats in Lakeview WMA to understand abiotic linkages to fish populations.

Methods

Sampling sites in Lakeview WMA were selected on 6/21/23 and consisted of three habitat types; two modified spawning pools (SP - LV SP1 & LV SP3) representing sites modified in 2024, two unmodified reference channels (REF - LV REF1 & LV REF2), and one unmodified SP (Figure 1). Within interior habitats at two Modified SP and REF sites we deployed 4 Onset U26 DO/TEMP data loggers to collect hourly dissolved oxygen (mg/l) and water temperature (°C) at midwater column (~40 cm). These loggers were used to assess abiotic conditions prior, during, and following associated fish surveys. We also placed a logger near the outlet of the wetland near the lake (LAKE) to assess conditions adjacent to the wetland.

Mini-hoop nets were set in connecting channels in each habitat type to survey for emigrating YOY and Y1 fishes. Each net completely blocked channel openings allowing us to assume that captured fish originated from these habitats. In 2023, netting was conducted during emigration period from 6/21/23 - 7/14/23 for a total of 16 net nights. While in 2024, netting was conducted from 6/10/24 - 6/28/24 for a total of 12 net nights. Sampling in 2024 was initiated earlier due to the extremely warm March 2024 weather triggering early spawning. Both time periods are representative of fish emigration patterns from Lakeview WMA and the impact of 2024 SP modifications.

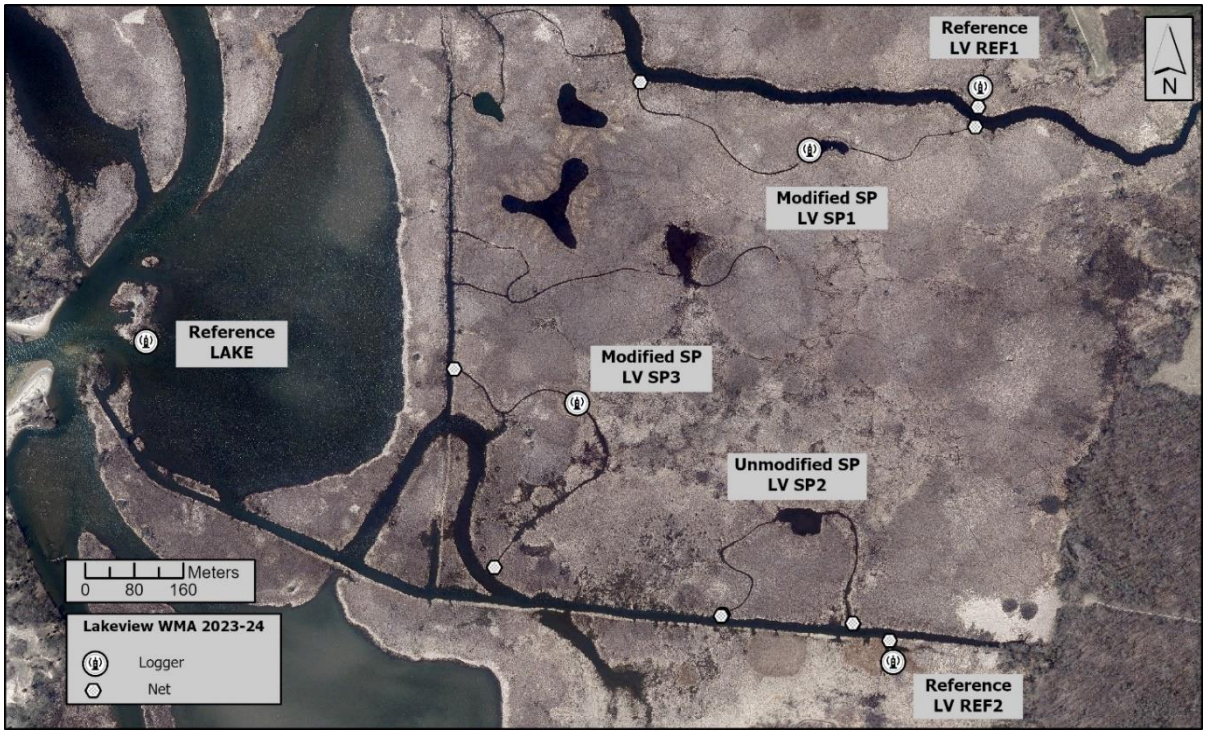

Figure 1. Sampling locations utilized for abiotic surveys utilizing DO/TEMP data logger array and mini-hoop net fish surveys to in Lakeview WMA in 2023 and 2024.

Results

Abiotic data summary

With the data logging array ~19,000 hourly measurements of DO and water temperature were taken over the extent of Lakeview WMA. Modified SP habitats exhibited patterns of diel DO change over very short time periods in 2023 and consistently again throughout sampling in 2024 (Figure 2). This 2024 diel pattern followed gradual increases in DO starting around 3-4 mg/l from early morning and peaking between 14:00 and 17:00 at around 6 mg/l. As water temperatures warmed, we saw all sites lose DO over the sampling period, only to start to regain DO into September 2023. Reference habitats during both years were consistently hypoxic (<3 mg/l) and only remained slightly oxygenated in LV REF 2 prior to sustained hypoxia at all sites (Figure 2). Diel patterns were similar between sampling years and habitat types, but stronger more consistent patterns were observed in Modified SP's. Water temperature followed similar diel patterns with the widest ranges demonstrated increases from 20°C at 5:00 to 25°C by 19:00 in 2024. While in 2023 the water temperature was colder and followed a much tighter range between 19°C and 22°C despite sampling during later time periods with typically warmer temperatures. Water temperatures in 2024 appeared to increase rapidly during the sampling period and likely would have increased past maximums recorded in 2023.

This data (Table 1) is summarized to represent daily values (min, mean, max) in sites grouped into modified SP, REF, and Lake habitats during fish emigration periods. Prior to restorations in 2023, Modified SP were similar to REF habitats and maintained anoxia (0 mg/l) despite water temperatures decreases fluctuating around ~21°C. Sampling during warmer water temperatures in 2024 showed short term variability and increases in water temperature with Modified SP almost 3°C warmer than REF habitats. However, in 2024 modified SP habitats had high DO with a mean 6.4 mg/l, while REF habitats were hypoxic (<3 mg/l) with a mean of 1.50 mg/l. Modified SP's appeared to maintain significantly more DO in 2023 in comparison to 2024 despite having warmer water temperatures.

Table 1. Dissolved oxygen (DO – mg/l) and water temperature (°C) recorded using Onset U26 DO/TEMP loggers in multiple habitat types in Lakeview WMA in 2023 and 2024 during fish emigration periods.

2023						
Type	Min. DO	Mean DO	Max. DO	Min. TEMP	Mean TEMP	Max. TEMP
Lake	1.27 ± 0.82	3.46 ±0.87	5.98 ± 1.43	23.82 ± 1.33	24.79 ± 1.34	26.10 ± 1.72
Modified SP	0.00 ± 0.00	0.00 ± 0.01	0.01 ± 0.06	20.63 ± 0.95	21.22 ± 0.93	22.23 ± 1.06
Reference	0.00 ± 0.00	0.01 ± 0.01	0.09 ± 0.14	20.94 ± 1.07	21.53 ± 1.00	22.42 ± 1.10
2024						
Type	Min. DO	Mean DO	Max. DO	Min. TEMP	Mean TEMP	Max. TEMP
Lake	1.68 ± 1.40	5.07 ± 1.63	8.95 ± 1.40	21.04 ± 3.21	22.70 ± 3.14	24.51 ± 3.14
Modified SP	4.84 ± 1.46	6.41 ± 0.95	7.70 ± 0.83	22.26 ± 3.55	24.23 ± 3.51	26.56 ± 3.42
Reference	0.41 ± 0.86	1.50 ± 2.01	3.41 ± 3.71	19.40 ± 2.94	20.91 ± 3.18	22.85 ± 3.70

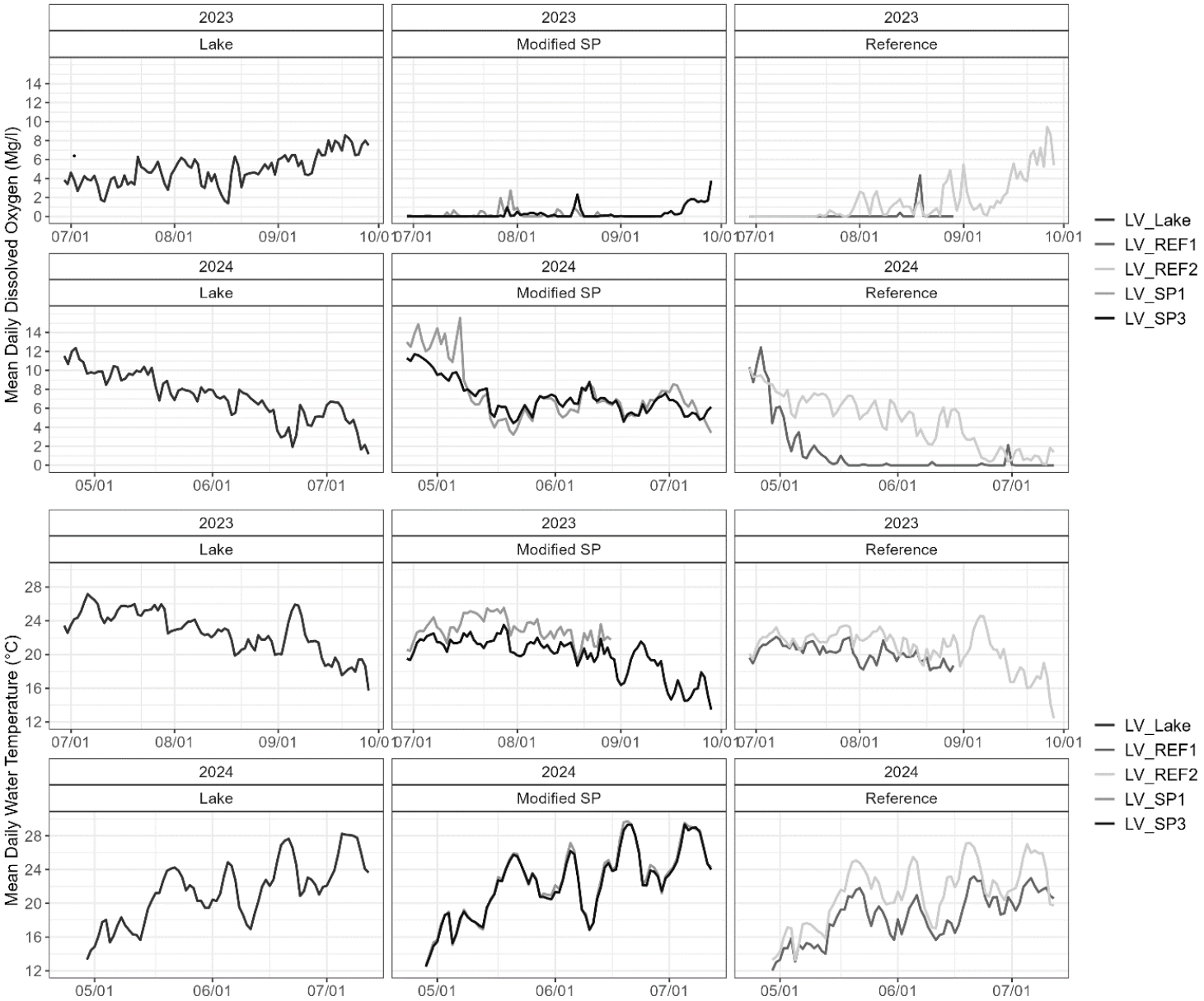

Figure 2. Time series of dissolved oxygen (DO – mg/l) and water temperature (°C) of three different habitat types (Lake, Modified SP, Reference) in 2023 and 2024. Note the difference in sampling periods on the x-axis. Below: Hobo logger used and typical deployment.

Fish Data Summary

In total 43,426 fish were captured in Lakeview WMA consisting of 849 Year-1 and older fish and 42,577 YOY fish comprising 20 different species (Table 2). In 2023, we captured 1,313 fish out of Modified SP while in 2023 we captured 13,183 fish, a ten-fold increase. While REF habitats total catch increased to 7,939 in 2023 to 12,477 in 2024. Unmodified SP also showed increases in fish capture from 1,725 in 2023 to 6,779 fish in 2024. During both years of surveying fish catch varied over time, with peaks occurring through sampling for multiple species. In Modified SP in 2023 we averaged 7.4 fish per net during the first 4 net nights and averaged 6.8 fish per net during the last 4 net nights. Modified SP's in 2024 allowed for a significant increase in catch, averaging 26.30 fish per net during the first 4 net nights and 39.20 fish per net during the last 4 net nights.

Focal species associated with high catches were standardized by number of nets per site and number of net nights per survey (CPUE) to help compare 2023 and 2024 between the habitat types (Figure 3). High catch species consisted of Largemouth Bass, Cyprinid species, Common Carp and were caught frequently in large quantities maxing out at 2,815 caught in one daily net check. In 2023, Cyprinids were the most captured fish species, with especially high numbers of fish being caught in REF habitats. Reference habitats also yielded high CPUE of Yellow Perch due to a few days of large pulses of this species. Largemouth Bass CPUE increased in both modified SP and REF sites from 2023 to 2024. Low catch species included Yellow Perch, Darter, Lepomis species, and Northern Pike which averaged 0.25 fish per day. Yellow Perch averaged the most fish per day in this grouping at 0.50 in REF habitats. Modified SP's had a larger CPUE in Northern Pike in 2023 but not in 2024 and was likely related to differences in conditions experienced by spawning adults. Modified SP's produced Darter species in 2024 that were not captured in 2023. Lepomis species were most consistent between each season maintaining between 0.2-0.5 CPUE with notable increase in catch in 2024 in comparison to 2023.

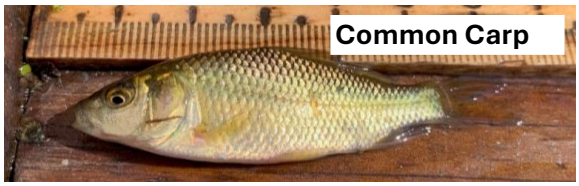

Table 2. Young-of-year and Year-1 fish species total catch by habitat type from Lakeview WMA sampling conducted from 6/21/23 - 7/14/23 (16 net nights) and 6/10/24 - 6/28/24 (12 net nights).

Young-of-year	Modified SP		Unmodified SP		Reference	
Species	2023	2024	2023	2024	2023	2024
Brown Bullhead - BBH (*Ameiurus nebulosus*)	0	1234	0	4461	0	446
Bowfin (*Amia ocellicauda*)	199	18	1	0	2	0
Brook Stickleback (*Culaea inconstans*)	0	7	1	0	2	1
Common Carp (*Cyprinus carpio*)	129	1106	0	20	67	88
Common Logperch (*Percina caprodes*)	0	5	0	0	0	69
Central Mudminnow (*Umbra limi*)	592	19	130	0	308	4
Chain Pickerel (*Esox niger*)	6	33	5	4	32	5
Cyprinid (*Notropis, Leuciscidae, Pimpheles*)	42	1286	1083	18	6658	38
Darter (*Etheostoma)*	0	139	0	0	0	11
Grass Pickeral (*Esox americanus vermiculatus)*	10	13	3	1	35	0
Northern Pike NP - (*Esox lucius*)	71	19	44	5	80	13
Largemouth Bass - LMB (*Micropterus salmoides*)	146	8522	401	184	1372	11611
Lepomis (*macrochirus, gibbous*)	0	138	7	0	4	43
Longnose Gar (*Lepisosteus osseus*)	0	2	0	0	0	0
White Sucker (*Catostomus commersonii*)	0	3	0	0	0	1
Yellow Perch YP- (*Perca flavescens*)	0	179	0	0	141	64

Year-1	Modified SP		Unmodified SP		Reference	
Species	2023	2024	2023	2024	2023	2024
Brown Bullhead BBH - (*Ameiurus nebulosus*)	15	4	19	6	15	5
Brook Stickleback (*Culaea inconstans*)	2	1	0	0	0	0
Bluegill (*Lepomis macrochirus*)	20	10	6	5	11	5
Central Mudminnow (*Umbra limi*)	405	350	33	24	33	25
Emerald Shiner (*Notropis atherinoides*)	9	8	11	11	0	0
Fathead Minnow (*Pimephales promelas*)	6	6	0	0	0	0
Golden Shiner (*Notemigonus crysoleucas*)	20	12	2	2	9	0
Pumpkinseed (*Lepomis gibbosus*)	47	25	43	37	33	14
Tadpole Madtom (*Noturus gyrinus*)	3	3	1	0	1	0
Yellow Perch YP - (*Perca flavescens*)	46	39	16	13	12	11

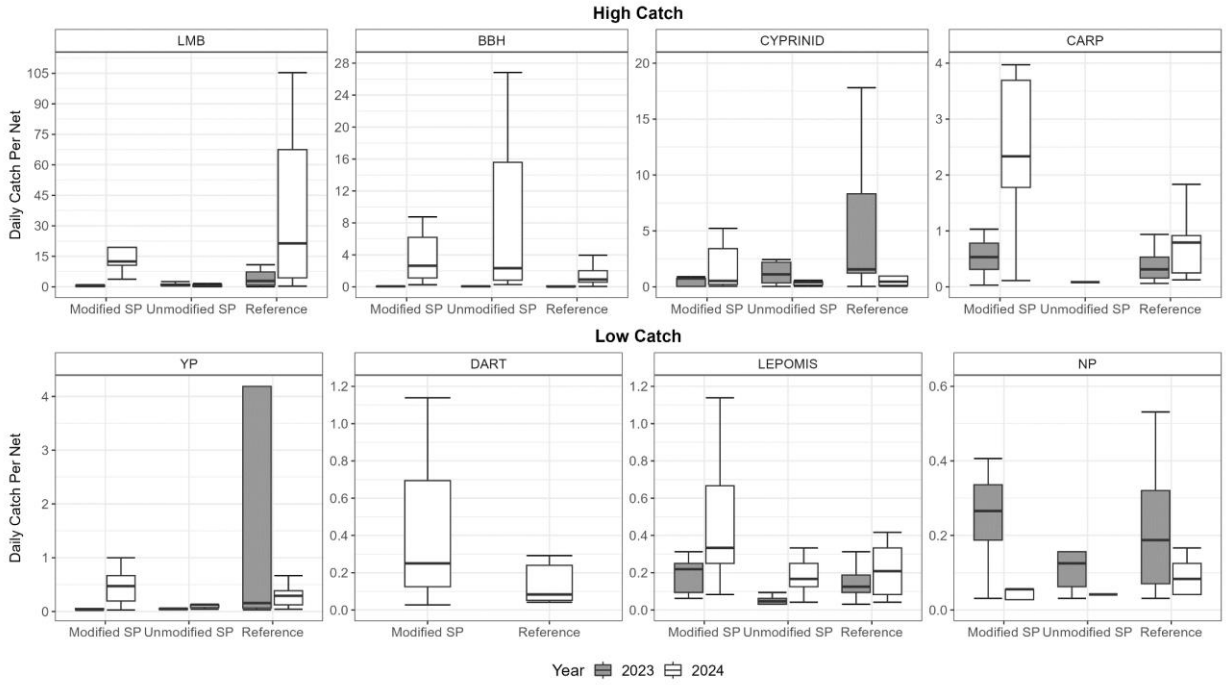

Figure 3. Daily catch per net of high catch species and low catch species focal species from Lakeview WMA sampling conducted from 6/21/23 - 7/14/23 (16 net nights) and 6/10/24 - 6/28/24 (12 net nights). Note the different x-axis scales based on species.

Statistical Comparison

Results from a Wilcox Rank-Sum test indicate significant differences ($p<0.05$) in mean CPUE between habitat types when comparing 2023 and 2024. Specifically, we saw a significant difference ($p=0.01$) in REF sites with means of CPUE of 0.4 fish per night in 2023 to 1.2 CPUE fish per night in 2024. Reference sites in 2024 had multiple large catches of LMB and Cyprinids during a few net checks causing there to be a larger range of CPUE. Modified SP's also had a significant difference ($p<0.01$) in CPUE between 2023 and 2024, where mean CPUE increased from 0.5 to 2.2 fish per night. Interestingly Unmodified SP showed no significant difference ($p=0.07$) in mean CPUE between years and was 0.5 and 0.6 fish per night, respectively. When comparing Modified SP CPUE to REF CPUE we saw a significant difference ($p=0.03$) in 2023 and no significant difference ($p=0.88$) in 2024 (Figure 4).

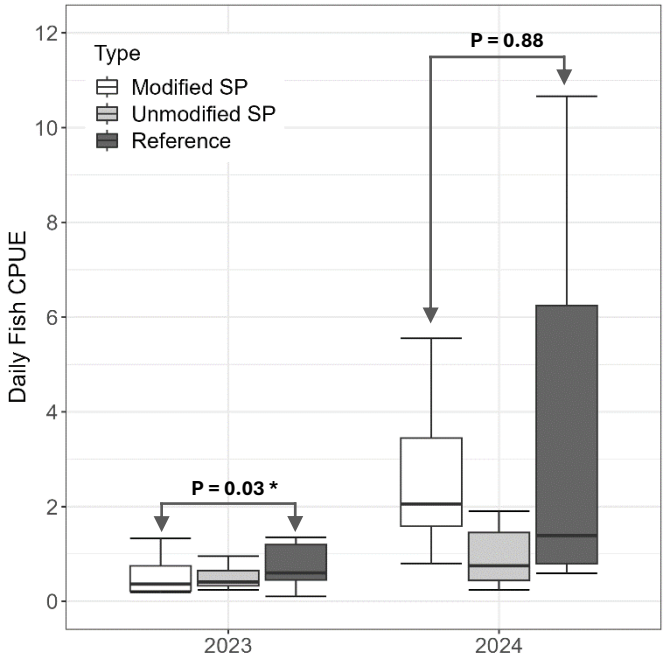

Figure 4. Daily Fish CPUE of all species captured in Lakeview WMA grouped by habitat and year. Statistically significant differences are indicated between daily fish CPUE between Modified SP and REF sites within a year.

Pearson Correlation Analysis using log transformed data was used to help understand the relationship between abiotic conditions, fish catch, and restoration impacts with both 2023 and 2024 datasets (Table 3). Significant correlations were found between DO mean and Mean CPUE in modified and REF habitats at moderate to strong correlations (0.55-0.77) indicating a relationship between mean daily DO and CPUE. Water temperature was not significantly correlated with mean CPUE and could be related to the interannual differences observed in water temperature.

Group	Parameter 1	Parameter 2	r	95% CI	P
Modified SP	DO mean	TEMP mean	0.29	-0.15 - 0.63	0.190
Modified SP	DO mean	Mean CPUE	0.77	0.51- 0.90	<0.01 *
Modified SP	TEMP Mean	Mean CPUE	0.39	-0.04 - 0.68	0.152
Reference	DO mean	TEMP mean	-0.20	-0.57 - 0.24	0.492
Reference	DO mean	Mean CPUE	0.55	0.16 - 0.79	0.025 *
Reference	TEMP Mean	Mean CPUE	0.26	-0.18 - 0.61	0.492

Table 3. Pearson's correlation analysis results using log-transformed capture data and dissolved oxygen (mg/l) and water temperature (°C) data from modified spawning pools and reference habitats in 2023 and 2024.

Conclusions

Abiotic conditions in Lakeview WMA are closely tied to seasonal conditions present in both 2023 and 2024. Sampling in 2023 was later in the emigration period and displayed seasonal hypoxia, anoxia, and high-water temperatures in all sites. While seasonal hypoxia is a natural wetland process it is likely exacerbated by decomposing *Typha* litter (Leblanc and Farrell, 2023) and it is important to monitor oxygen conditions when making habitat modifications. Modified SPs appeared to produce slightly more DO, consistent with project expectations, with various spikes occurring throughout our sampling. Although short, these spikes could provide much needed refugia for aquatic species and may represent significant oxygen production by aquatic plants growing in open water SP habitats. Reference habitats like LV REF 1 remained anoxic the entire sampling period and were very clogged with aquatic SAV and *Typha,* limiting water mixing and photosynthesis-derived oxygen. While LV REF 2 habitats had higher DO and was less blocked with *Typha*. It appears that increasing open water habitat like in Modified SP can influence the production of DO, increase water temperatures leading to positive aquatic production, and providing structural habitat for the aquatic community. Large increases to modified SP open water habitat likely facilitated higher DO levels in 2024 and potentially could have sustained DO longer into August than in 2023 despite the earlier start to seasonal spring warming.

Restorations to SP's in Lakeview WMA appeared to have a significant influence on the fish community. When comparing catch between 2023 and 2024 we saw large increases at modified SP and REF sites. In addition, modified SP CPUE was not statistically different than REF sites in 2024, although prior to restorations these sites were statistically different in CPUE. This result indicates the positive benefits of enhancements as they are comparable to REF fish production. Modified SP catches included large pulses of important recreational angling species such as LMB and important forage fish such as Cyprinids, all essential for the Lake Ontario fish community. Additionally, sensitive species such as Darter and Logperch were captured in Modified SP's in 2024 that were not observed in 2023. These benthic species have experienced serious declines in parts of the Great Lakes due to losses associated with invasion of Round Goby, and additional wetland habitat may help support these and other native fish populations. Unmodified SP had no significant difference in fish catch between 2023 and 2024 and helps provide evidence of the newly restored SP habitats, while still supporting existing restoration success. These differences in catch may be associated with interannual variability in year class strength, as seen in Northern Pike; or in abiotic conditions causing earlier 2024 fish emigration. Continued monitoring in these habitats could tease out interannual differences observed in this study. Modified SP in Lakeview WMA likely provided significantly more spawning habitat for Lake Ontario fishes and YOY fish nursery habitat.

When considering how abiotic conditions could potentially impact fish catch, we observed correlations between mean daily DO and fish CPUE in both types of habitats. These moderate

relationships helped solidify our conclusions about restoration success. Changes to Modified SP's in 2024 likely created more DO production which is significantly correlated to fish CPUE. These habitats appeared to respond to increased DO resulting in increases in fish production and diversity. Water temperature was not correlated to fish CPUE and was variable between the years potentially weakening this relationship. Modified SP's facilitated warmer water temperatures likely from the sunlight warming up these shallow exposed pools. Despite being slightly warmer these habitats sustained DO and likely provide ideal nursery habitats for YOY fishes. Focusing on maintaining DO and sufficient water temperatures should be the focus of future restorations expanding SP habitats. Creating large open water habitats like in Lakeview WMA would likely cause increases in fish CPUE if sufficient DO was maintained in the SP. Creating pools with enough depth refugia, high SAV production, and wide channels are likely important for keeping beneficial abiotic conditions. Notably, all species with exception of common carp introduced in the 19th century, are native species. Non-native fish species may dominate fish biomass in pelagic, profundal and in littoral embayments however, coastal wetlands have predominately native forms and habitat enhancements appear to improve abiotic conditions and use by fishes. We conclude, in the short-term, restorations conducted in Lakeview WMA in 2024 provided positive benefits for the aquatic abiotic conditions and the associated fish community.

Acknowledgements

We thank Andrew Hinickle for his conceptual and administrative support of this project. We are also indebted to the NYS Department of Environmental Conservation for their support of this research and access to the Lakeview Marsh WMA, in particular Irene Mazzochi and Timothy Pysczynski and NYSDEC Albany for assistance with collection permits. Matt Wagner of Ducks Unlimited for his service in the project design and accepting feedback. We also thank Jenifer Degen of Audubon and Lauren Vanderzee of ESF for help with contracting and administrative support. Andrew Parnas and staff of the ESF Thousand Islands Biological Station participated in the success of this work. This work received PROTOCOL FOR THE HUMANE USE OF LIVE VERTEBRATES, ESF Institutional Animal Care & Use Committee permit#200602.

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