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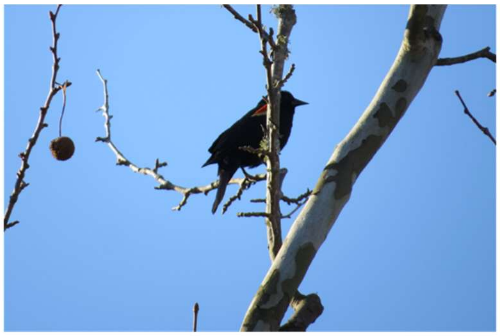
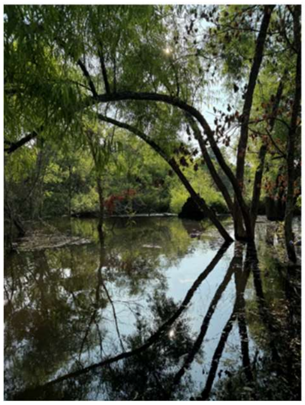
East Tennessee Technology Park Biological Monitoring and Abatement Program 2024 Calendar Year Report

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January 2025

OAK RIDGE National Laboratory

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Environmental Sciences Division

EAST TENNESSEE TECHNOLOGY PARK
BIOLOGICAL MONITORING AND ABATEMENT PROGRAM
2024 CALENDAR YEAR REPORT

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CONTENTS

LIST OF FIGURES iv
LIST OF TABLES v
ABBREVIATIONS vii
1. INTRODUCTION 1
2. TASK 1: BIOACCUMULATION MONITORING 4
   2.1 MITCHELL BRANCH 6
   2.2 K-1007-P1 POND 11
   2.3 K-901-A POND 16
   2.4 K-720 SLOUGH 18
   2.5 POPLAR CREEK AND OFF-SITE 21
3. TASK 2: INSTREAM BENTHIC MACROINVERTEBRATE COMMUNITY MONITORING 26
   3.1 MITCHELL BRANCH—ORNL AND TDEC PROTOCOLS 27
   3.2 COMPARISON BETWEEN MITCHELL BRANCH AND OTHER REFERENCE SITES ON THE ORR 34
4. TASK 3: FISH COMMUNITY MONITORING 37
   4.1 MITCHELL BRANCH 37
   4.2 K-1007-P1 POND FISH COMMUNITY 43
5. REFERENCES 46

LIST OF FIGURES

Figure 1. Map showing the major aquatic environments around ETTP. 2
Figure 2. Map of Mitchell Branch showing the locations of biological monitoring sites in relation to select storm drains. 3
Figure 3. Mean total concentrations (µg/g, wet wt) of PCBs (1993–2024; top) and Hg (2009–2024; bottom) in the soft tissues of caged Asiatic clams deployed in Mitchell Branch. 7
Figure 4. Total Hg and MeHg concentrations (µg/g, wet wt) in the soft tissues of caged Asiatic clams deployed in Mitchell Branch, 2009–2024. 9
Figure 5. Mean concentrations (µg/g, wet wt; ±1 standard error) of Hg and PCBs (bottom) in redbreast sunfish fillets in Mitchell Branch (MIK 0.2), 1989–2024.. 10
Figure 6. Means for total PCB (ng/L; ± standard deviation) and TSS (mg/L) concentrations in water, 2007–2024... 11
Figure 7. Aqueous PCB concentrations (ng/L) in 2024 at upper and lower SD100 compared with the K-1007-P1 outfall, K-901-A outfall, and First Creek reference site...................................... 12
Figure 8. Mean total PCB concentrations (µg/g wet wt) in caged clams placed at the K-1007-P1 Pond outfalls compared with reference stream clams (Little Sewee Creek), 1993–2024............. 13
Figure 9. Mean total PCB concentrations (µg/g wet wt ± standard error) in caged clams placed in and around the K-1007-P1 Pond (locations shown from east to west) compared with reference stream clams (Little Sewee Creek), 2024... 14
Figure 10. Mean PCB concentrations (µg/g, wet wt ± standard error) in fish from the K-1007-P1 Pond, 2007–2024. 15
Figure 11. Mean total PCB concentrations (µg/g, wet wt; ± 1 standard deviation) in whole-body fish from the K-1007-P1 Pond, K-901-A Pond, and K-720 Slough, 2009–2024. 16
Figure 12. Mean total PCB concentrations (µg/g, wet wt; ±1 standard error) in largemouth bass fillets from the K-901-A Pond, 1993–2024. 17
Figure 13. Mean total PCB concentrations (µg/g wet wt) in the soft tissues of caged Asiatic clams deployed in the K-901-A Pond compared with reference stream clams (Little Sewee Creek, shown in yellow), 1993–2024. 18
Figure 14. Mean total PCB concentrations (µg/g, wet wt) in the fillets of largemouth bass, common carp, and smallmouth buffalo collected from the K-720 Slough, 2009–2024. 19
Figure 15. Average PCB and Hg concentrations (µg/g, wet wt) in channel catfish from the Clinch River, Poplar Creek, and Tennessee River, 1986–2024. 22
Figure 16. Total Hg concentrations (µg/g, wet wt; ±1 standard error) in bluegill sunfish fillets collected in Poplar Creek, 1987–1994. 23
Figure 17. Total Hg concentrations (µg/g, wet wt; ±1 standard error) in the fillets of sunfish collected in Poplar Creek, 2006–2024. 24
Figure 18. Spatial trends in Hg concentrations (µg/g, wet wt) in the fillets of sunfish collected around Poplar Creek, FY 2024. 25
Figure 19. Collecting an invertebrate sample using ORNL BMAP protocols.. 26
Figure 20. Mean total taxonomic richness and taxonomic richness of the pollution-intolerant EPT taxa (mayflies, stoneflies, and caddisflies; bottom) for the benthic macroinvertebrate communities at sites in Mitchell Branch, April 1987–2024, collected using ORNL protocols.. 29
Figure 21. Mean percent density of the pollution-intolerant EPT taxa (stoneflies, mayflies, and caddisflies; top) and that of the pollution-tolerant Orthocladiinae midge larvae (Chironomidae; bottom) at sites in Mitchell Branch, April 1987–2024, collected using ORNL protocols.. 30
Figure 22. Temporal trends in the TDEC Macroinvertebrate Index (top) and the TDEC habitat scores (bottom) for sites in Mitchell Branch, August 2008–2024. 32

Figure 23. Temporal trends in components that comprise the TDEC habitat scores for sites in Mitchell Branch, August 2008–2024. 33
Figure 24. Mean total taxonomic richness (top) and taxonomic richness of the pollution-intolerant EPT taxa (mayflies, stoneflies, and caddisflies; bottom) for the benthic macroinvertebrate communities at sites in Mitchell Branch, April 2005–2024, collected using ORNL protocols. 35
Figure 25. Mean percent densities of the pollution-intolerant taxa (i.e., stoneflies, mayflies, and caddisflies; top), and of the pollution-tolerant Orthocladiinae midge larvae (Chironomidae; bottom) at sites in Mitchell Branch, April 2005–2024, collected using ORNL protocols. 36
Figure 26. Construction of lined section of Mitchell Branch, MIK 0.7, in 1998 (top), and more recent habitat conditions in 2024 (bottom). 38
Figure 27. Species richness (number of species) for the fish communities at sites in Mitchell Branch and in reference streams Mill Branch, Scarboro Creek, and Ish Creek, 1987–2024. 39
Figure 28. Density (fish/m^2) for the fish communities at sites in Mitchell Branch and in reference streams Mill Branch, Scarboro Creek, and Ish Creek, 1987–2024. 39
Figure 29. Biomass (g/m^2) for the fish communities at sites in Mitchell Branch and in reference streams Mill Branch, Scarboro Creek, and Ish Creek, 1987–2024. 40
Figure 30. Sensitive species (e.g., banded sculpin and snubnose darter) richness (number of species) of the fish communities at sites in Mitchell Branch and in reference streams Scarboro Creek and Ish Creek, 1991–2024. 41
Figure 31. Sensitive species (e.g., banded sculpin and snubnose darter) density (fish/m^2) in the fish communities at sites in Mitchell Branch and in reference streams Scarboro Creek and Ish Creek, 1991–2024. 42
Figure 32. Sensitive fish species observed in lower Mitchell Branch. 42
Figure 33. Changes in the K-1007-P1 Pond fish community (% composition) from 2007 to 2024. 44

LIST OF TABLES

Table 1. Average concentrations (µg/g, wet wt) of total PCBs (Aroclors 1248, 1254, and 1260) and Hg_T in fillets and whole-body composites of fish collected in 2024 near ETTP. 20
Table 2. Stream sites included in the comparison between Mitchell Branch and other reference sites on the ORR. 27
Table 3. Tennessee Macroinvertebrate Index (TMI) metric values and scores, index score, and narrative ratings for Mitchell Branch, August 6, 2024.[a,b] 31
Table 4. Numbers of nuisance fish removed from the K-901-A Pond, 2024. 45

ABBREVIATIONS

AWQC	ambient water quality criterion
BMAP	Biological Monitoring and Abatement Program
CRM	Clinch River mile
EFK	East Fork Poplar Creek kilometer
EFPC	East Fork Poplar Creek
EPA	US Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, and Trichoptera
ETTP	East Tennessee Technology Park
FCK	First Creek kilometer
FFK	Fifth Creek kilometer
GHK	Gum Hollow Branch kilometer
ISK	Ish Creek kilometer
MBK	Mill Branch kilometer
MeHg	Methylmercury
MIK	Mitchell Branch kilometer
NRWQC	National Recommended Water Quality Criterion
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PCK	Poplar Creek kilometer
PCM	Poplar Creek mile
SCK	Scarboro Creek kilometer
SD	Storm Drain
TDEC	Tennessee Department of Environment and Conservation
TMDL	total maximum daily load
TMI	Tennessee Macroinvertebrate Index
TSS	total suspended solids
WCK	White Oak Creek kilometer
TRM	Tennessee River mile
WBK	Walker Branch kilometer
WRRP	Water Resources Restoration Program
Y-12	Y-12 National Security Complex

1. INTRODUCTION

The East Tennessee Technology Park (ETTP) Biological Monitoring and Abatement Program (BMAP) consists of three tasks that reflect different but complementary approaches to evaluating the ecological integrity of waters near ETTP. These tasks include (1) bioaccumulation monitoring of fish and clams, (2) benthic macroinvertebrate species richness and density monitoring, and (3) fish community monitoring.

The sampling and analysis requirements for the ETTP BMAP in calendar year 2024, covering in part both FY 2024 and FY 2025, are outlined in the respective FY sampling and analysis plans (UCOR 2023, 2024). Sampled water bodies and locations for the ETTP BMAP are shown in Figures 1 and 2.

This ETTP BMAP report presents the CY 2024 results and provides context with results from previous years. The report also includes Oak Ridge National Laboratory (ORNL)–generated biological monitoring data collected for other US Department of Energy programs, including the UCOR Water Resources Restoration Program (WRRP) off-site fish bioaccumulation data (UCOR 2023) and select Y-12 National Security Complex (Y-12) BMAP fish bioaccumulation data. Historical data collected for the ETTP BMAP and other programs in the nearby Poplar Creek and Clinch River are provided where appropriate.

This progress report provides an update on the biological monitoring activities supporting the ETTP UCOR Environmental Compliance organization, which sponsors the ETTP BMAP. In addition to this internal reporting, ETTP BMAP results are provided in the annual remediation effectiveness reports and the annual site environmental reports, both of which are publicly available. BMAP data are also available to the public via the Oak Ridge Environmental Information System (https://ucor.com/oak-ridge-environmental-information-system-oreis/).

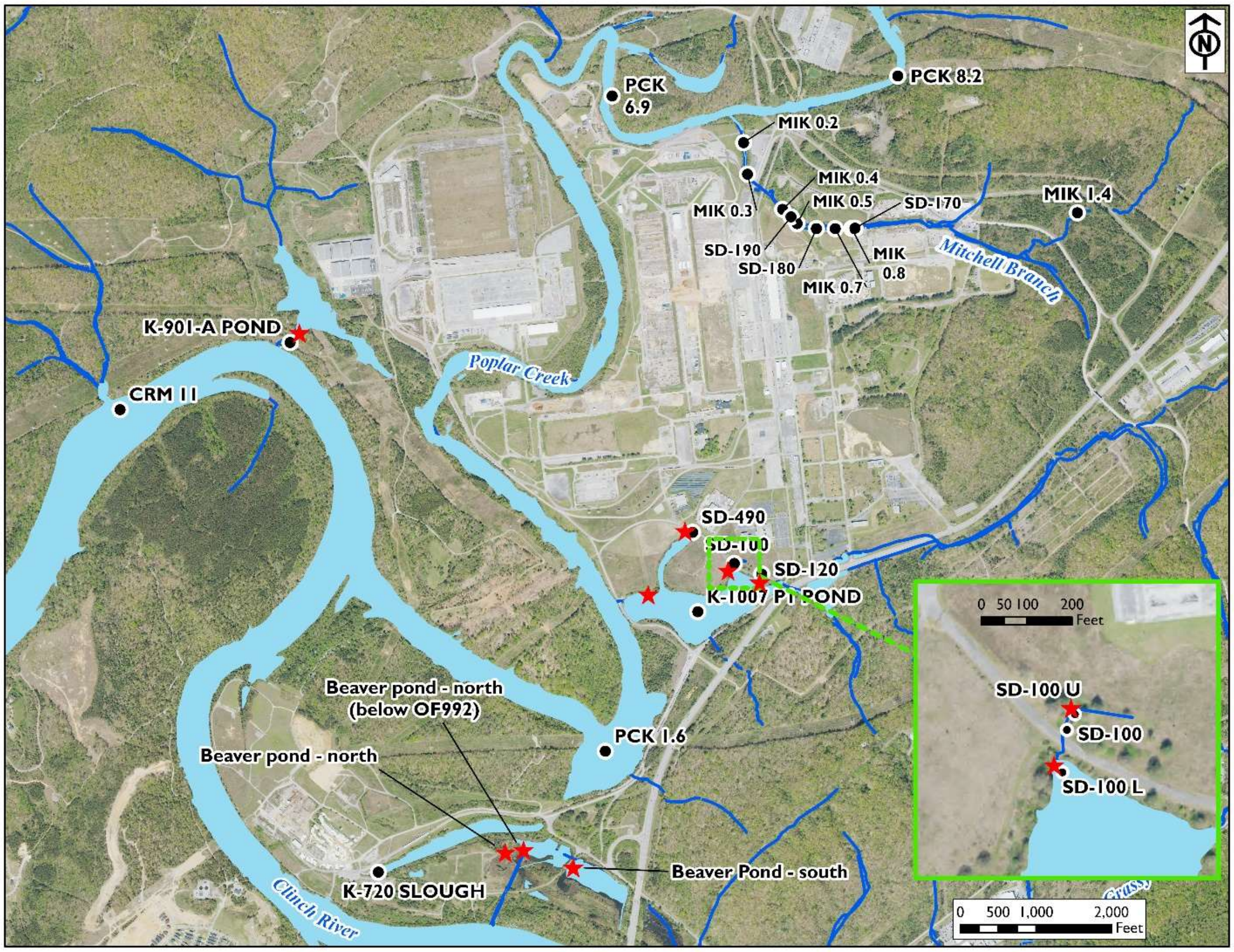


Figure 1. Map showing the major aquatic environments around ETTP.

Red stars indicate clam sampling locations in and around the K-1007-P1 Pond, K-901-A Pond, and Poplar Creek in 2024. (MIK = Mitchell Branch kilometer; PCK = Poplar Creek kilometer; CRM = Clinch River mile; SD = Storm Drain.)

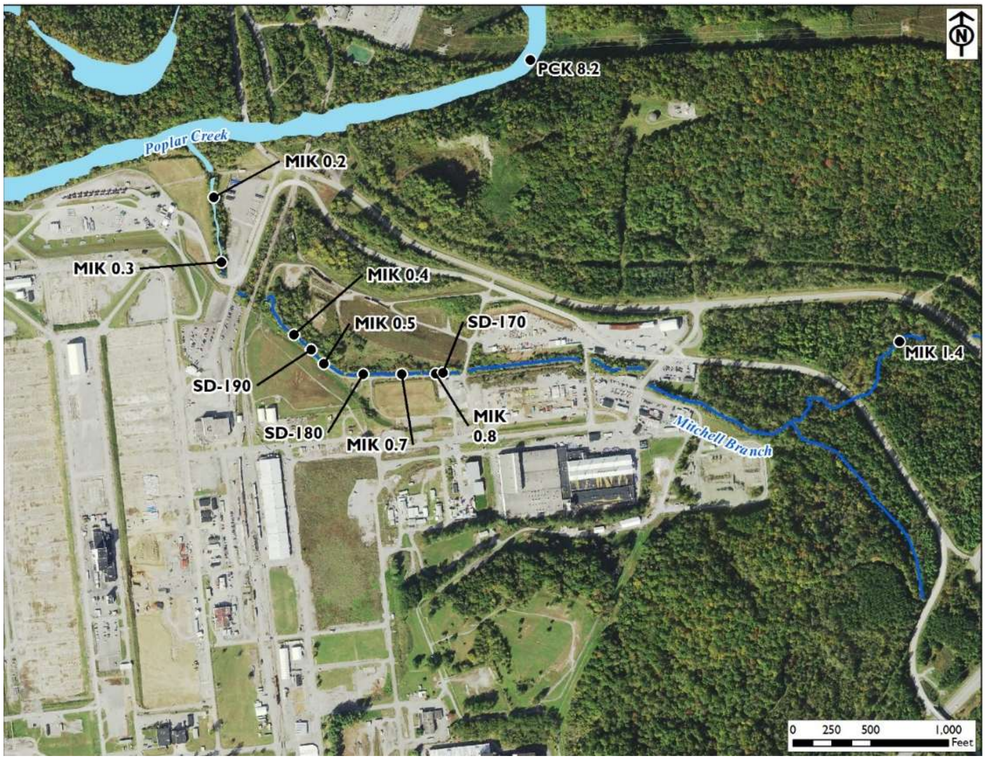


Figure 2. Map of Mitchell Branch showing the locations of biological monitoring sites in relation to select storm drains. (MIK = Mitchell Branch kilometer; PCK = Poplar Creek kilometer; SD = Storm Drain.)

2. TASK 1: BIOACCUMULATION MONITORING

Bioaccumulation monitoring for the ETTP BMAP focuses on evaluating the impact of polychlorinated biphenyl (PCB) discharges into the environment as a result of historical operations at the ETTP complex. Mercury flux into Poplar Creek and the Clinch River was previously assumed to originate largely from Y-12 discharges into East Fork Poplar Creek (EFPC). However, over the past decade, monitoring has shown that water in ETTP storm drains and biota from lower Mitchell Branch have elevated Hg concentrations. Mercury bioaccumulation monitoring is routinely conducted in the watersheds adjacent to ETTP by the Y-12 and ORNL BMAPs, both on and off the Oak Ridge Reservation (ORR). The available Hg bioaccumulation monitoring data are presented in the following subsections with long-term trends in PCB contamination in resident fish and caged clams from ETTP waters. Recent tabular results are provided in the FY 2024 ETTP BMAP report.

Because the consumption of contaminated fish represents the largest dose of Hg and many other bioaccumulative contaminants to humans, fish fillet Hg and PCB concentrations are relevant when assessing human health risks, whereas whole-body fish concentrations are relevant for assessing ecological risks. Although most Hg in the environment is inorganic Hg, a small proportion of total Hg (Hg_T) is microbially transformed to methylmercury (MeHg) in aquatic ecosystems. Methylmercury is highly bioaccumulative, becoming incorporated into protein-rich tissues (e.g., muscle) and becoming increasingly concentrated as it is transferred through the food chain. The consumption of Hg-contaminated fish is this toxin's primary route to humans. Therefore, the US Environmental Protection Agency's (EPA's) National Recommended Water Quality Criterion (NRWQC) for Hg is based on fish tissue concentrations (0.3 µg MeHg/g fish fillet) because the tissue concentration is considered a more consistent indicator of exposure and risk. Also, because MeHg is typically >95% of the Hg_T in fish fillets (Bloom 1992), the Hg_T concentrations in fish fillets is commonly used as a proxy for MeHg concentrations: Hg_T analysis is more straightforward (and less costly). When Hg_T concentrations are close to tissue guidelines, it is possible that MeHg concentrations are below the guideline, which may affect determinations of impairment in water bodies.

Largemouth bass (*Micropterus salmoides*) and various sunfish species were used to monitor fillet concentrations of Hg and PCB, while gizzard shad (*Dorosoma cepedianum*) and bluegill sunfish (*Lepomis macrochirus*) were used to monitor whole-body concentrations at various locations over time. Largemouth bass are large, upper–trophic level predatory fish and are therefore susceptible to Hg and PCB bioaccumulation. Fillet Hg and PCB concentrations in these fish represent the near-maximum potential dose to humans. Largemouth bass tend to live in larger, deeper pools of water and were collected in the ponds at ETTP (K-901-A Pond and K-720 Slough), as well as in off-site river and reservoir locations. Sunfish are short-lived and have small home ranges, so fillet Hg and PCB concentrations in these fish are representative of exposure at the site of collection. These fish are used in long-term studies to monitor changes in bioaccumulation at a given site over time. Collections of sunfish were restricted to sizes large enough to be taken by sport anglers (generally 50–150 g total weight) to minimize the effects of covariance between size and contaminant concentrations, as well as for spatial and temporal comparability. The target sunfish species for bioaccumulation studies in Mitchell Branch and other ORR stream sites was redbreast sunfish (*Lepomis auritus*), but where these fish were not present, other species with similar feeding habits (e.g., bluegill sunfish) were collected.

For bioaccumulative contaminants such as Hg and PCBs, fish bioaccumulation data have become important measures of compliance for both the Clean Water Act and the Comprehensive Environmental Response, Compensation, and Liability Act. As mentioned above, the NRWQC for Hg in fish of 0.3 µg/g is used as the trigger point for fish consumption advisories in Tennessee, the target concentration for National Pollutant Discharge Elimination System permit compliance, and the threshold for impairment designations that require a total maximum daily load (TMDL) assessment. In addition to fish Hg limits, the state of Tennessee continues to use the statewide ambient water quality criterion (AWQC) for Hg of 51 ng/L in water, based on organisms only, and 50 ng/L for recreation water and organisms (Tennessee Department of Environment and Conservation 2024).

Regulatory guidance and human health risk levels have varied more widely for PCBs than for Hg, depending on the regulatory program and the assumptions used in the risk analysis. The Tennessee water quality criteria for individual Aroclors and total PCBs are both 0.00064 µg/L under the recreation-designated use classification and are the target for PCB-focused TMDLs, including for local reservoirs (i.e., Melton Hill, Watts Bar, and Fort Loudon) (Tennessee Department of Environment and Conservation 2010a, 2010b, 2010c). However, the detection limits of most conventional PCB water analyses are much higher than the PCB AWQC. Therefore, in Tennessee and many other states, assessments of impairment for water body segments, as well as public fishing advisories for PCBs, are based on fish tissue concentrations. In the past, the US Food and Drug Administration threshold limit of 2 µg/g in fish fillets was used for PCB advisories; then, for many years in Tennessee, an approximate range of 0.8 to 1 µg/g was used, depending on the data available and factors such as fish species and size. The remediation goal for fish fillets at the ETTP K-1007-P1 Pond is 1 µg/g, and for whole-body fish the goal is 2.3 µg/g. Most recently, the water quality criterion has been used by the Tennessee Department of Environment and Conservation (Tennessee Department of Environment and Conservation 2019) to calculate the fish tissue concentration triggering a determination of impairment and a TMDL, and this concentration is 0.02 µg/g in fish fillets (Tennessee Department of Environment and Conservation 2010a, 2010b, 2010c). The fish PCB concentrations at and near ETTP are well above this most conservative concentration.

In addition to monitoring for human health and ecological risks and long-term trends, bioaccumulation monitoring also includes investigations of sources of contamination in ETTP waterways. Caged Asiatic clams (*Corbicula fluminea*) are used as bioindicators of contaminant sources in Mitchell Branch and other sites around ETTP. These clams are collected from an uncontaminated reference site (i.e., Little Sewee Creek in Sweetwater, Meigs County, Tennessee). In 2024, clams were placed in baskets to be deployed at strategic locations around ETTP (i.e., in and around storm drains) for a four-week exposure period (May 7 – June 4, 2024). Two clam baskets were placed at each site, and each basket contained 10 clams.

Because clams are sedentary filter feeders, they accumulate contaminants that are present in the water and suspended particles at a given site. They are useful indicators of the bioavailable (and therefore potentially toxic) portion of contaminants that enter the environment at a given location, and they provide spatial resolution of contamination on a finer scale than is possible with fish bioaccumulation studies. Caged clams have been used for more than 25 years to evaluate the importance of storm drains and other inputs of PCBs into the waterways around ETTP, and they have been used for the past 10+ years to monitor Hg_T and MeHg inputs to Mitchell Branch. Whereas most of the Hg in the environment is inorganic Hg (Hg(II)), a small fraction of Hg(II) is converted to the more toxic and bioaccumulative MeHg. Because MeHg biomagnifies in aquatic systems, increasing in concentration as it moves up through the food chain, more than 95% of the Hg in upper–trophic level fish is MeHg (Bloom 1992). Clams, which feed on periphyton and detritus at the base of the food chain, have a much smaller proportion of MeHg in their tissues but are still good indicators of MeHg hot spots and sources. The soft tissues of the clams from each cage were homogenized, and aliquots were taken for PCB and Hg analysis.

To assess spatial and temporal variability in exposure to PCBs following remediation activities, water samples were collected to analyze aqueous PCBs and total suspended solids (TSS) from the outfall of K-1007-P1 Pond and an uncontaminated reference site (upper First Creek, ORNL). Samples are collected from the K-1007-P1 Pond four times each year (March, June, July, and August) and from First Creek two times each year (June and August). In 2024, water samples were also collected four times (April, June, July, August) from Storm Drain (SD) 100 to evaluate PCB inputs into the K-1007-P1 Pond. For PCBs, 2 L of water was collected in certified clean 1 L amber glass bottles and held in a secure refrigerator until delivery to a subcontract laboratory for analysis of 209 congeners using EPA Method 1668. TSS samples were collected concurrently with PCB samples in clean 1 L Nalgene bottles and were processed at ORNL on the same day.

2.1 MITCHELL BRANCH

Mitchell Branch was classified as an impaired stream for recreation (US Environmental Protection Agency 2022). The Tennessee Department of Environment and Conservation (TDEC 2024) lists the causes of impairment as PCBs, dissolved oxygen and physical substrate habitat alterations.

Figure 3 shows long-term monitoring results in caged clams at various sites in Mitchell Branch. The lower portion of this stream (i.e., Mitchell Branch kilometer [MIK] 0.5 [SD190]–MIK 0.2) has historically been a hot spot for both Hg and PCB contamination. In 2024, PCB concentrations at lower Mitchell Branch sites decreased slightly at all sites, except MIK 0.5, when compared to the 2023 concentrations but broadly remained below concentrations seen before 2016. Although considerable interannual variability was observed, PCB concentrations in clams placed in the lower portion of Mitchell Branch appear to be generally trending downward since the peak years of 2000 and 2001. PCB concentrations in the upper portion of Mitchell Branch (MIK 0.8) were comparable to 2023 concentrations and similar (0.03 μg/g) to those recorded at the reference site (0.01 μg/g).

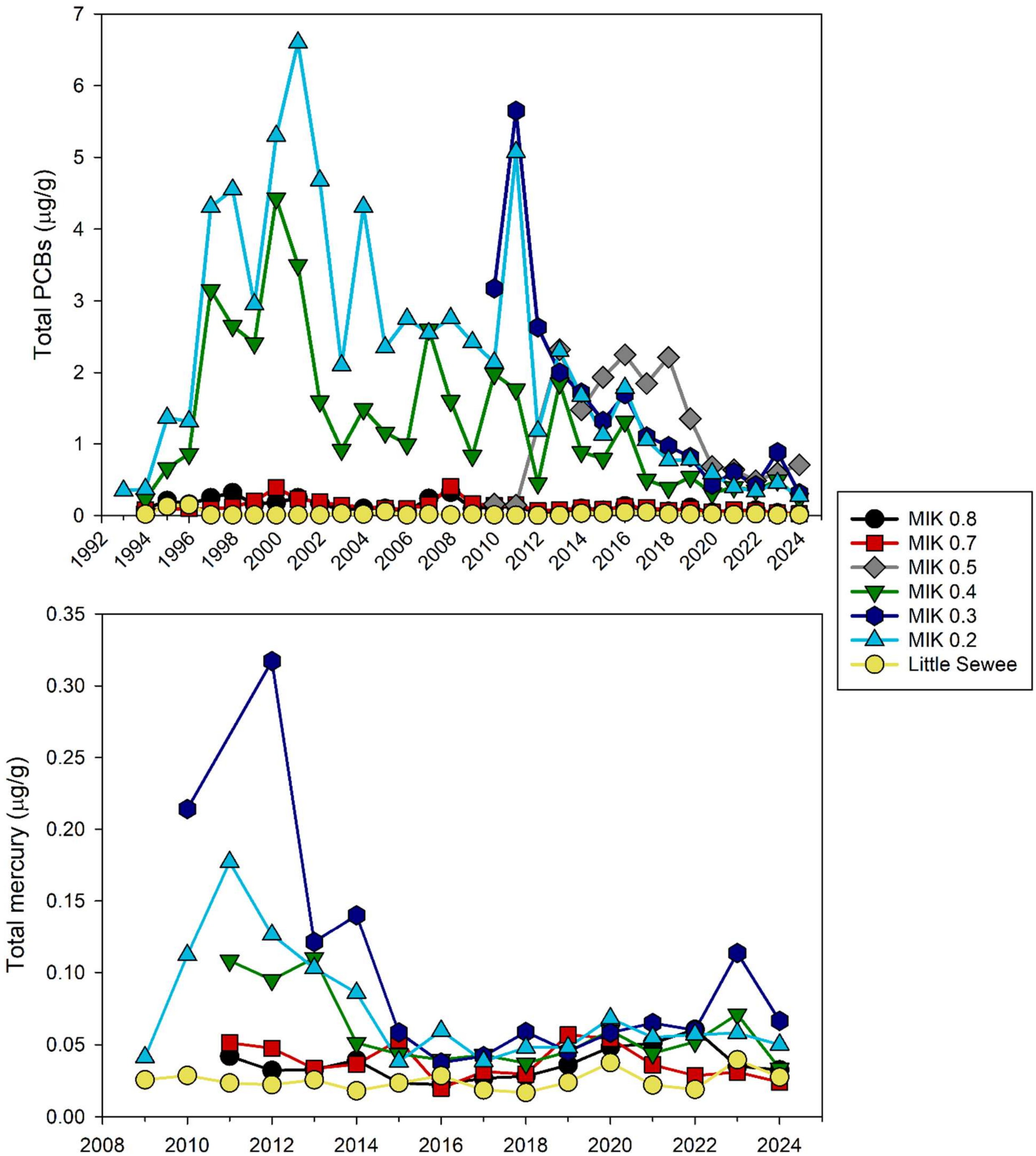


Figure 3. Mean total concentrations (µg/g, wet wt) of PCBs (1993–2024; top) and Hg (2009–2024; bottom) in the soft tissues of caged Asiatic clams deployed in Mitchell Branch. N = 2 composites of 10 clams each per year. Little Sewee Creek (data shown in yellow) is the reference site. Total PCBs are defined as the sum of Aroclors 1248, 1254, and 1260.

Surface water monitoring conducted by various programs (e.g., UCOR Environmental Compliance, WRRP) has shown that aqueous Hg concentrations in Mitchell Branch can fluctuate significantly. This level of variability is typical of stream systems because aqueous Hg concentrations can change with various environmental factors (e.g., flow, suspended solids) and sample collection methods. Variation in aqueous Hg concentrations is not uncommon; a grab sample taken on a certain day thus reflects a snapshot of the conditions during that sampling period. Research at ORNL has found changes in aqueous Hg concentrations between day and night, for example. Additionally, the relationship between aqueous Hg concentrations and MeHg concentrations is not straightforward, leading to further complexities regarding Hg bioaccumulation. Although monitoring aqueous concentrations is still indicative of the relative importance of different Hg sources to a given watershed, bioaccumulation data reflect an integrative measure of the bioavailable portion of Hg exposure at a given site. Monitoring MeHg concentrations in clams highlights the complexity of Hg bioaccumulation: whereas Hg_T concentrations in clams varied greatly between sites, MeHg concentrations in Mitchell Branch were elevated compared with those of the reference site but varied less than the Hg_T between sites or between years.

Mercury concentrations in clams deployed in Mitchell Branch in 2024 were similar to the concentrations seen in 2023, except at MIK 0.3 and 0.4, where Hg concentrations decreased by nearly half (from 0.11 to 0.07 µg/g and from 0.07 to 0.03 µg/g, respectively; Figure 3). In 2024, Hg concentrations in all other Mitchell Branch sites were only slightly higher than those recorded at the reference site. Within the Mitchell Branch system, the highest Hg concentrations were seen in clams deployed at SD180 (0.10 µg/g). Unlike in fish tissue, MeHg in the soft tissues of clams generally made up a small proportion of Hg_T (Figure 4). Methylmercury concentrations in clams remained low in 2024, comparable to concentrations in 2023.

Figure 5 shows long-term monitoring results in redbreast sunfish at MIK 0.2. Average PCB concentrations in fish collected at MIK 0.2 in 2024 (0.41 ± 0.09 µg/g) were similar to those seen in 2023 (0.59 ± 0.08 µg/g) and are among the lowest concentrations reported for the past 30 years at this site (Figure 5, bottom). Although no regulatory limit exists for PCBs in fish, the level most often used in practice to issue fish consumption advisories in the state of Tennessee is 1 µg/g, as previously stated. In 2024, the mean PCB concentration in sunfish fillets remained below this limit. Although the observed fish tissue concentrations in Mitchell Branch are lower than they have historically been, they are still two to three orders of magnitude higher than concentrations seen in the same species at the Hinds Creek reference site, and they are above the fish tissue concentration (0.02 µg/g in fish fillets) calculated using the water quality criterion (0.00064 µg/L), triggering an impairment classification (Tennessee Department of Environment and Conservation 2010a, 2010b, 2010c).

Total Hg has been monitored more sporadically than PCB concentrations in redbreast sunfish fillets at MIK 0.2. Figure 5 (bottom) shows long-term trends in Hg_T concentrations (µg/g) in these fish. A rapid increase in fillet Hg_T concentrations was observed in the early 1990s, and concentrations have generally remained elevated: mean concentrations have exceeded the AWQC (0.3 µg/g) in most years. Similar to the PCB concentrations in fish from this site, Hg_T concentrations in fish collected from MIK 0.2 have oscillated around the EPA-recommended AWQC for the past several years, and they remained above the tissue criterion for Hg, averaging 0.49 ± 0.05 µg/g in 2024.

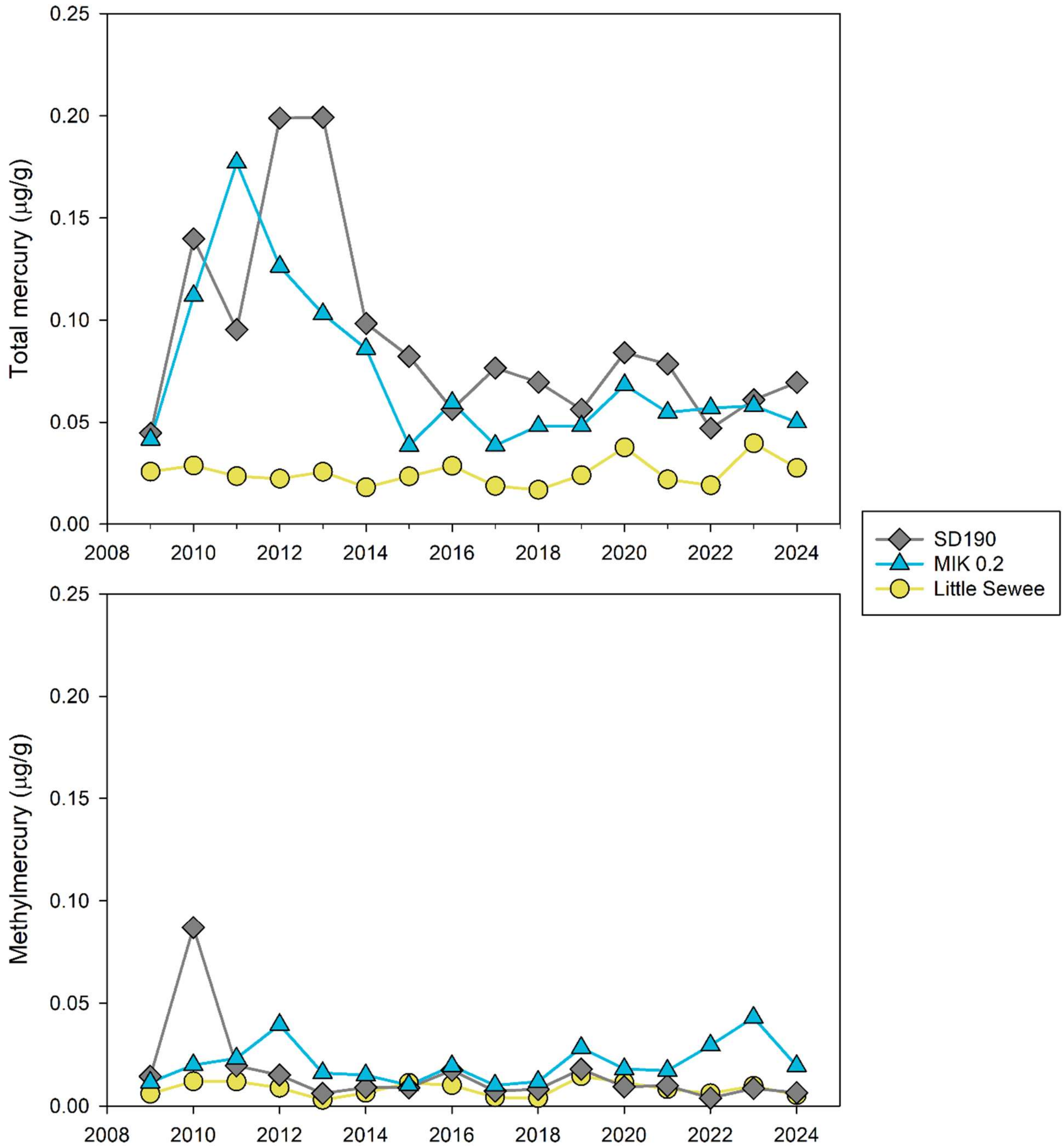
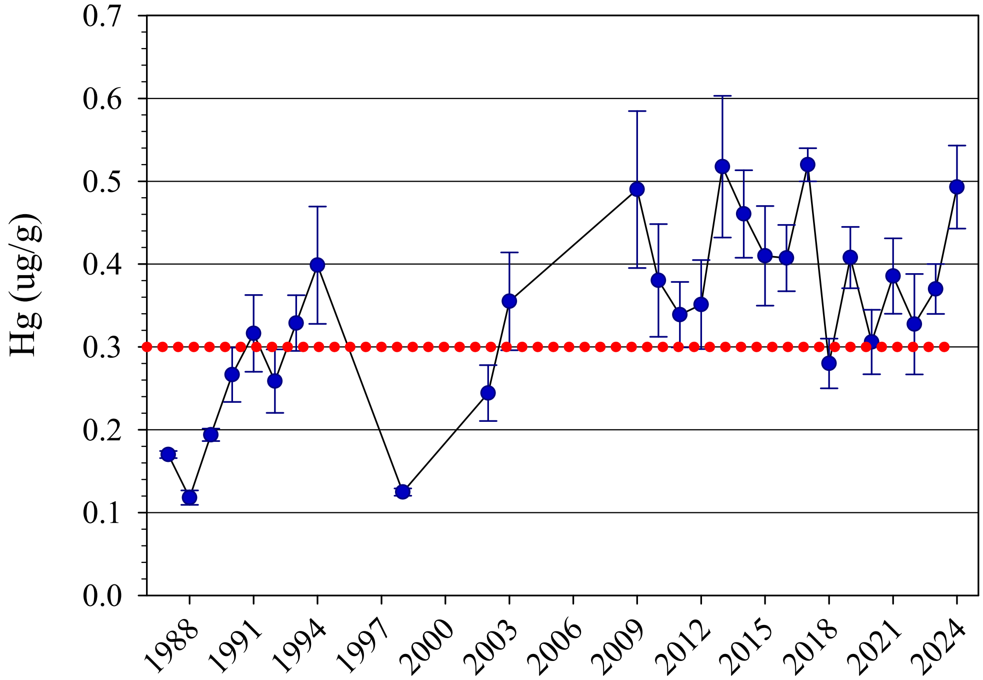


Figure 4. Total Hg and MeHg concentrations (µg/g, wet wt) in the soft tissues of caged Asiatic clams deployed in Mitchell Branch, 2009–2024. N = 2 composites of 10 clams each per year. Little Sewee Creek (data shown in yellow) is the reference site.



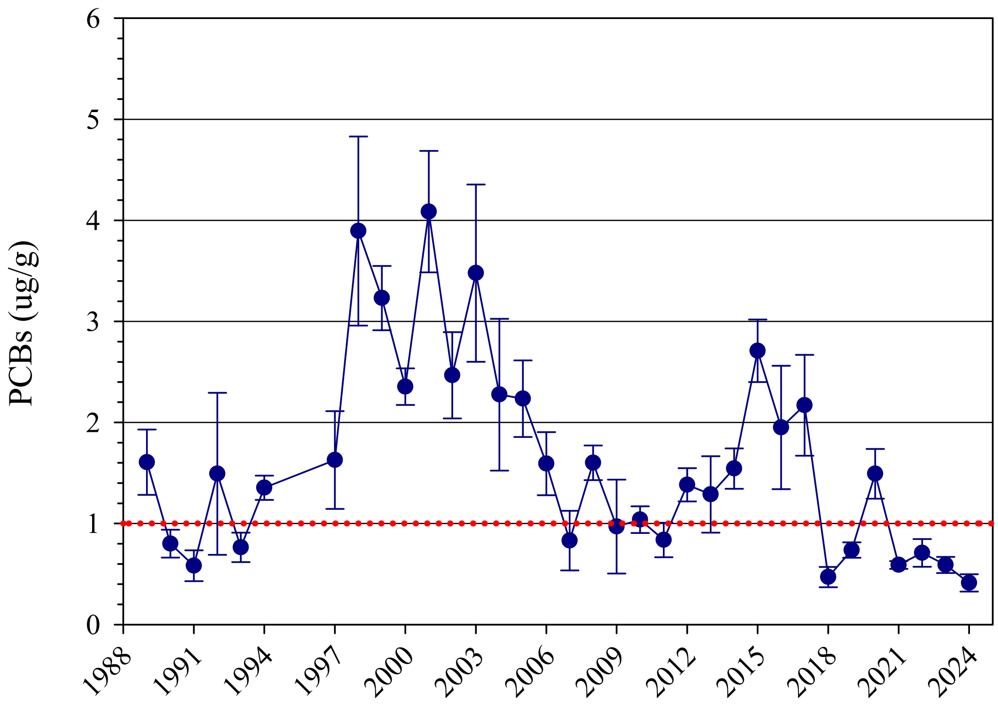


Figure 5. Mean concentrations (µg/g, wet wt; ±1 standard error) of Hg and PCBs (bottom) in redbreast sunfish fillets in Mitchell Branch (MIK 0.2), 1989–2024. N = 6 fish per year. The red dotted line signifies the fish advisory level for PCBs (1 µg/g) and Hg (0.3 µg/g).

2.2 K-1007-P1 POND

Over the past decade, mean aqueous PCB concentrations in the K-1007-P1 Pond have fluctuated significantly but have generally been lower than concentrations seen before 2009 remediation activities (e.g., 35 ng/L in 2024 compared with 161 ng/L in 2007; Figure 6). Concentrations in 2024 were within the ranges observed over the past decade. As hydrophobic contaminants, PCBs tend to be particle-associated and are positively correlated with TSS. The fluctuations in PCB and TSS concentrations in water in the K-1007-P1 Pond could be related to fluctuations in aquatic plant coverage, which can affect sediment stability. The fluctuations in TSS and PCBs could also be partially or wholly caused by fluctuations in aqueous PCB inputs from SD100 (Figure 7).

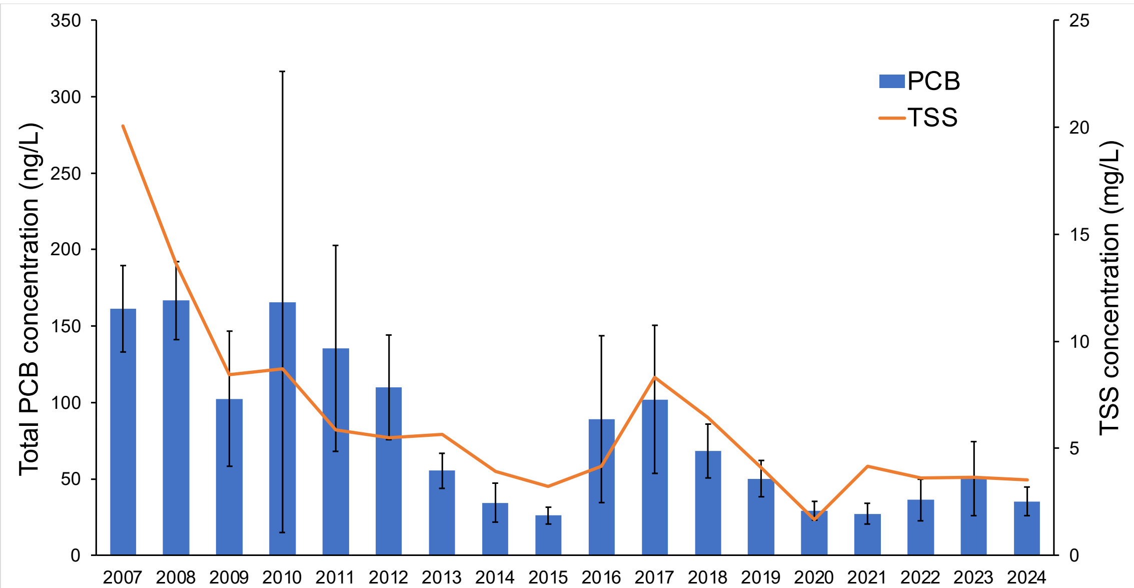


Figure 6. Means for total PCB (ng/L; ± standard deviation) and TSS (mg/L) concentrations in water, 2007–2024. Means for PCBs and TSS are based on the results across all collections made each year. Mean concentrations of PCBs in water from a reference site, First Creek, were <1.5 ng/L in all years and are not shown here. For reference, the chronic AWQC for aqueous PCBs for the protection of fish and aquatic life is 14 ng/L.

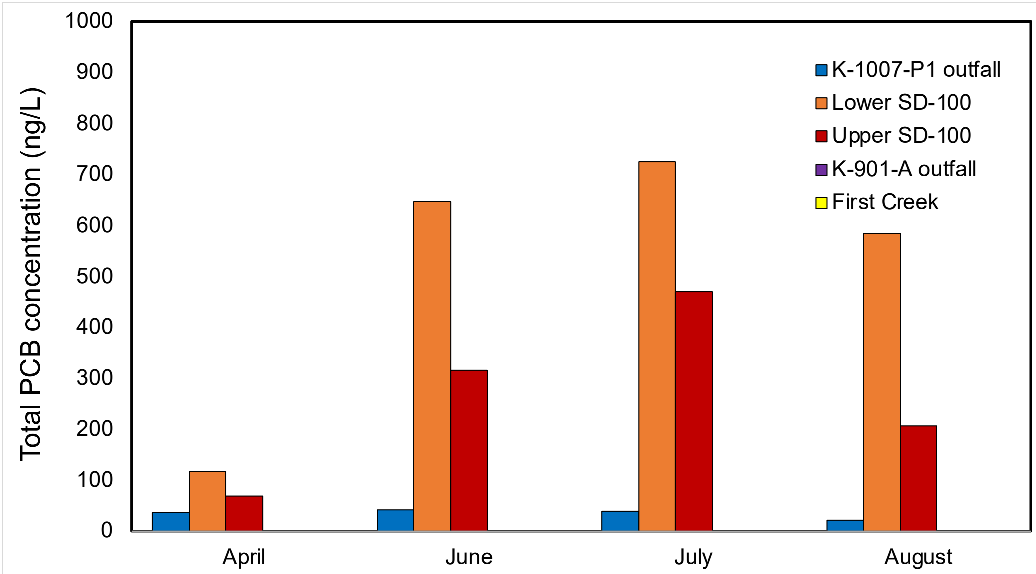


Figure 7. Aqueous PCB concentrations (ng/L) in 2024 at upper and lower SD100 compared with the K-1007-P1 outfall, K-901-A outfall, and First Creek reference site. Concentrations of PCBs in water from First Creek and the K-901-A Pond outfall were <1.6 ng/L in all samples. Samples were collected from First Creek only in June and August.

PCB concentrations in clams placed at lower and upper SD100 locations (Figure 8, bottom) have fluctuated significantly since 1995, but they were on an overall decreasing trajectory from 2007- 2017. PCB concentrations in clams deployed at this site increased significantly in 2021–2023, but in 2024, they decreased significantly at upper SD100 (from 9.9 µg/g to 3.3 µg/g), returning to the range of concentrations recorded from 2008 to 2021. PCB concentrations at upper SD100 have been below values found at lower SD100 for the entire monitoring period, a trend that continued in 2024: concentrations decreased slightly while remaining somewhat elevated from concentrations seen from 2006 to 2021. Although PCB concentrations in clams placed at the K-1007-P1 Pond outfall are an order of magnitude lower than those deployed at upper SD100, concentrations here followed the same temporal trends as those at SD100 locations, with a slight increase 2022 and 2023 followed by a decrease in 2024 (Figures 8 and 9). PCB concentrations at SD120 and SD490 remained similar to values recorded since 2012. Total Hg and MeHg concentrations in clams deployed at the K-1007-P1 Pond were nearly two times higher than concentrations in clams deployed at the reference site, Little Sewee Creek.

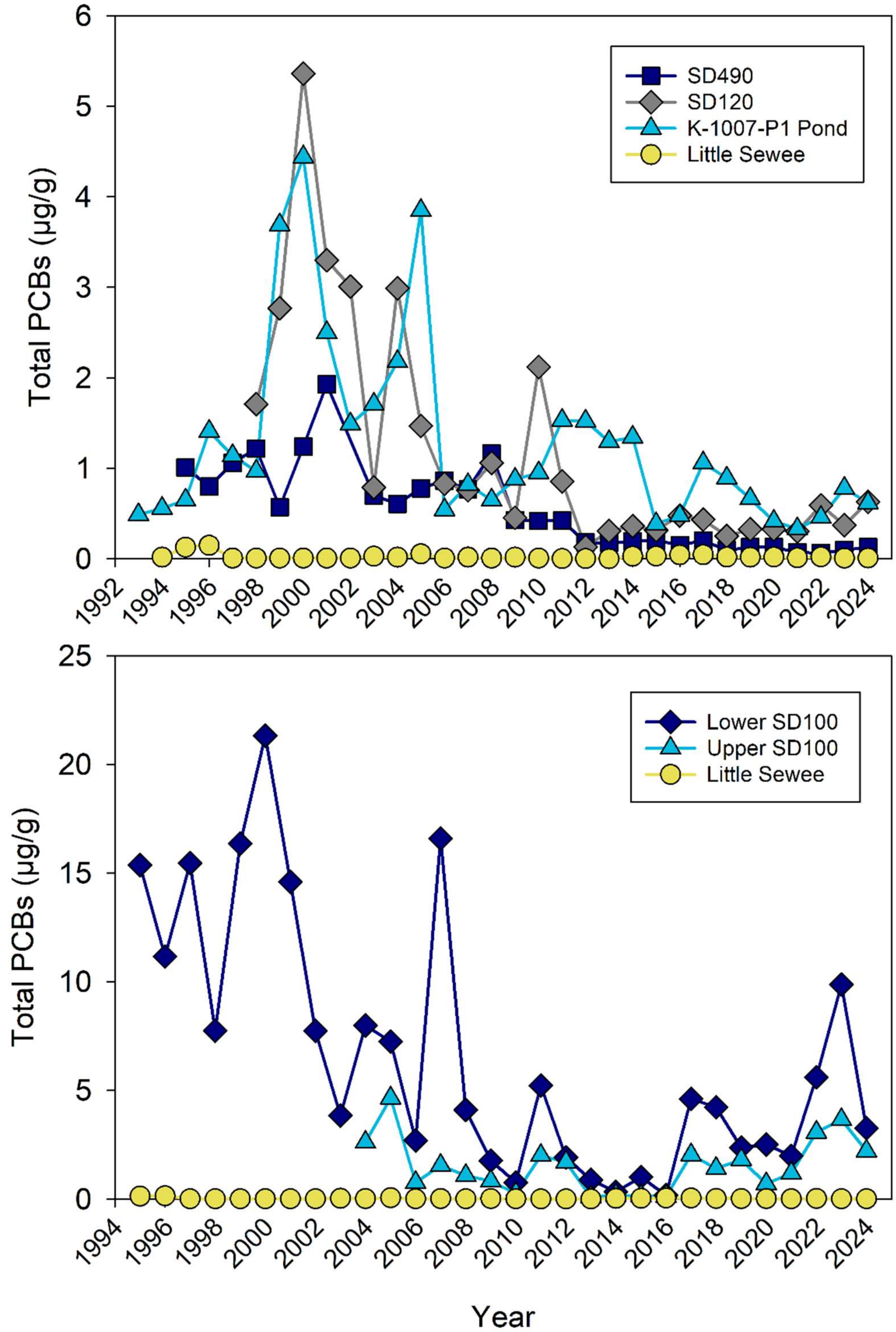


Figure 8. Mean total PCB concentrations (µg/g wet wt) in caged clams placed at the K-1007-P1 Pond outfalls compared with reference stream clams (Little Sewee Creek), 1993–2024. N = 2 clam composite samples per site/year. Total PCBs are defined as the sum of Aroclors 1248, 1254, and 1260.

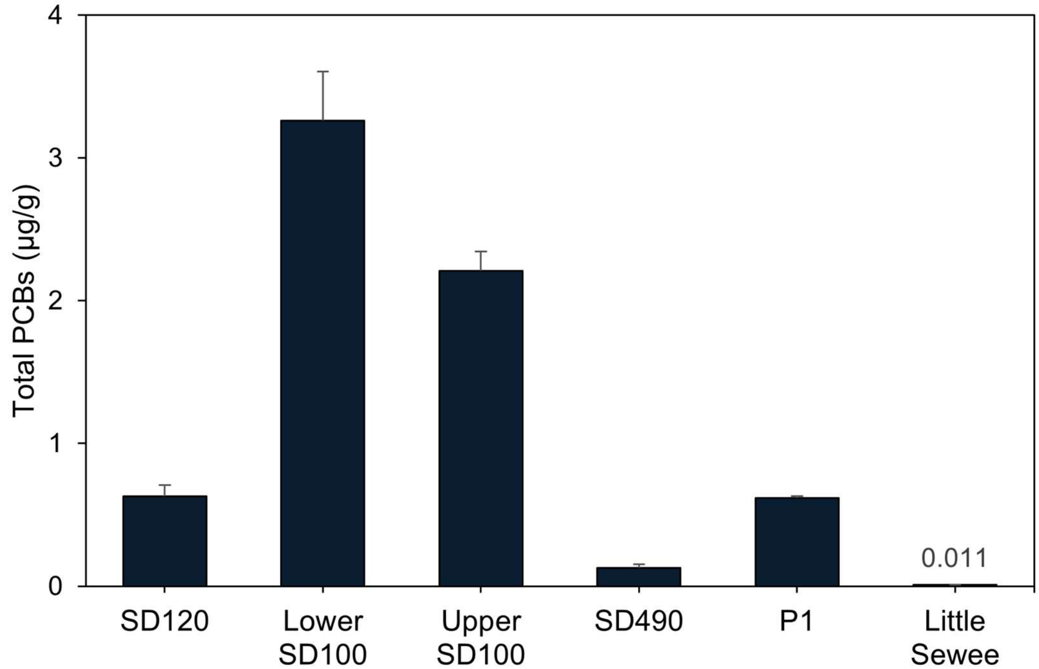


Figure 9. Mean total PCB concentrations (µg/g wet wt ± standard error) in caged clams placed in and around the K-1007-P1 Pond (locations shown from east to west) compared with reference stream clams (Little Sewee Creek), 2024. N = 2 clam composite samples per site/year. Total PCBs are defined as the sum of Aroclors 1248, 1254, and 1260.

Average PCB concentrations in biota collected from the K-1007-P1 Pond appear to be generally decreasing despite significant fluctuations in the 15 years post-remediation (Figure 8, Figure 10). In FY 2024, mean PCB concentrations in both fillets and whole-body composites of bluegill were below the targets for the K-1007-P1 Pond. Mean PCB concentrations in fillets in the K-1007-P1 Pond were 0.22 µg/g in 2024, which is below the remediation goal for this pond (1 µg/g total PCBs in fillets). The mean concentration in whole-body bluegill was 1.00 µg/g in 2024, which is below the remediation target for this pond (2.3 µg/g in whole-body composites; Figure 11).

The observed fluctuations in biota PCB concentrations suggest that this system is still in transition and that further decreases in PCB bioaccumulation may become apparent as the fish and plant communities stabilize.

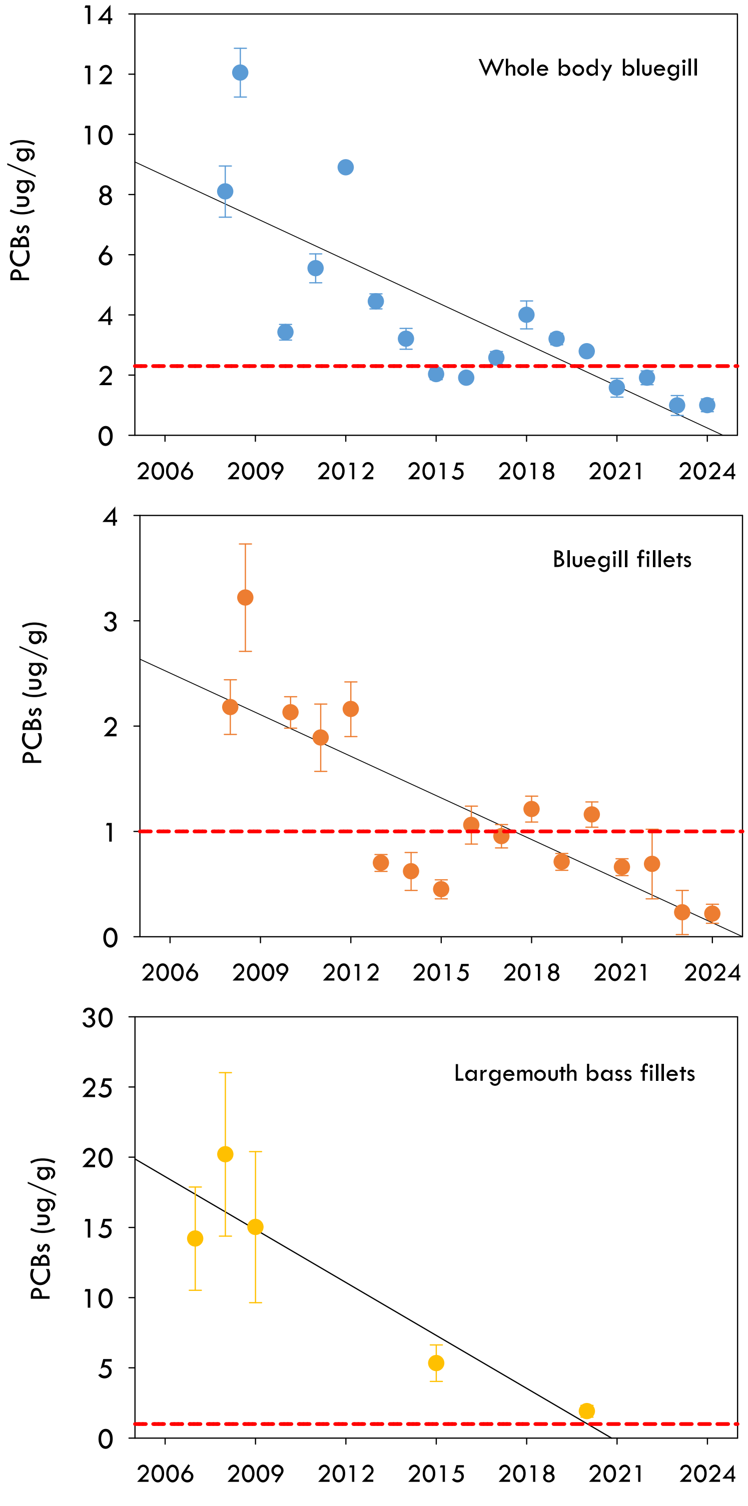


Figure 10. Mean PCB concentrations (µg/g, wet wt ± standard error) in fish from the K-1007-P1 Pond, 2007–2024.

For largemouth bass, N = 6 fish per site/year. For bluegill sunfish, N = 20 for fillets and N = 6 composites of 10 whole-body fish. The red dotted lines signify the targets for fillet (1 µg/g) and whole-body concentrations (2.3 µg/g).

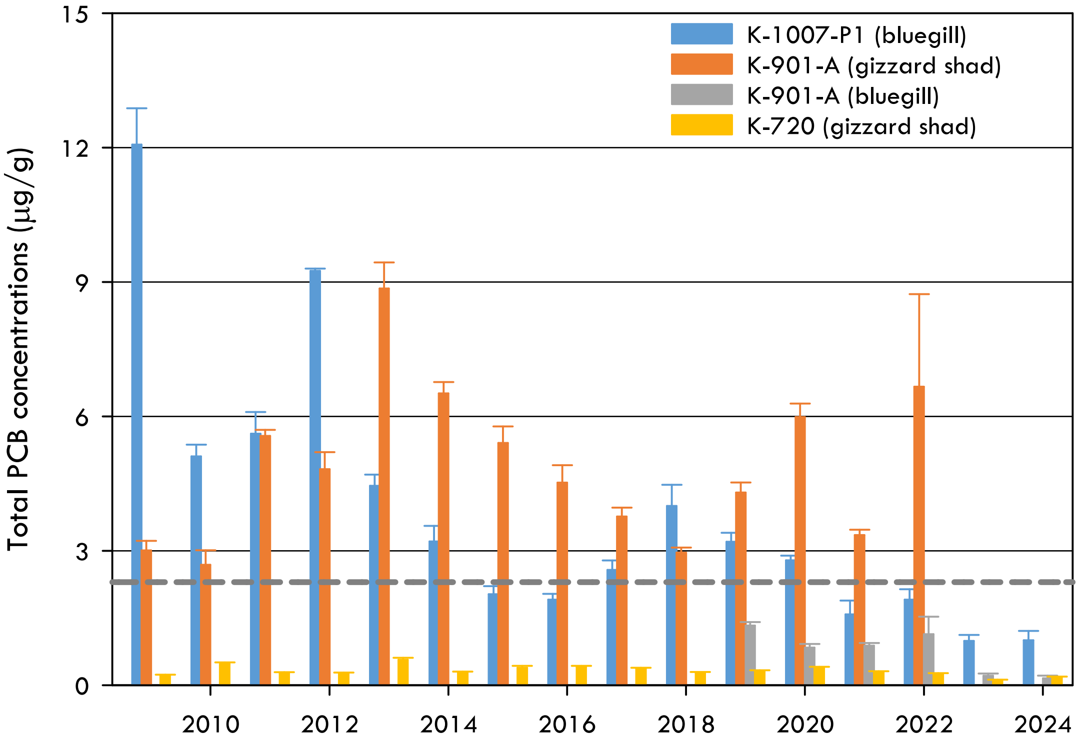


Figure 11. Mean total PCB concentrations (µg/g, wet wt; ± 1 standard deviation) in whole-body fish from the K-1007-P1 Pond, K-901-A Pond, and K-720 Slough, 2009–2024. Total PCBs are defined as the sum of Aroclors 1248, 1254, and 1260. The dashed line signifies the target PCB concentration of 2.3 µg/g in whole-body fish.

2.3 K-901-A POND

The target fish species for PCB analysis in the K-901-A Pond and K-720 Slough were gizzard shad (*D. cepedianum*) and largemouth bass (*M. salmoides*). In 2023-2024 gizzard shad were not available to collected from the K-901-A Pond. This was due to nuisance fish removal efforts begun in 2018 as well as extensive aquatic plant growth covering the pond and limiting suitable habitat for gizzard shad. Therefore, bluegill were collected from the K-901-A Pond for analysis of fillets and whole-body tissue. Bluegill and gizzard shad were also collected from Clinch River mile (CRM) 11.0 and Poplar Creek mile (PCM) 1.0 for analysis of whole-body tissue. It was not possible to collect the target number of bass (20) from the K-901-A Pond and K-720 Slough; therefore, common carp (*Cyprinus carpio*) were collected to provide a combined total of 20 fish. Carp were selected as surrogate species for bass because they are widely distributed and they have been used historically in other monitoring efforts on the ORR for contaminant analyses. A total of 1 carp and 14 largemouth bass were collected from the K-901-A Pond, and 16 bass and 3 carp were collected from the K-720 Slough in 2024.

At the K-901-A Pond, the total PCB concentrations in carp were higher in 2024 (1.69 µg/g) than those seen in carp in 2023 (0.54 µg/g). PCB concentrations in largemouth bass declined significantly from 0.46 µg/g in 2023 to 0.05 µg/g in 2024, remaining below the target concentration of 1 µg/g total PCBs set for the K-1007-P1 Pond (Figure 12). Mean concentrations in bluegill fillets (0.08 µg/g) and whole-body composites (0.15 µg/g) collected from the K-901-A Pond were lower than those in the K-1007-P1 Pond.

PCB concentrations in clams deployed in the K-901-A Pond were considerably lower than those deployed in the K-1007-P1 Pond (0.6 and 0.02 µg/g, respectively) and have been generally declining since 2016 to near–reference site concentrations in 2024 (Figure 13). Aqueous PCB samples were collected at the K-901-A Pond in April, June, July, and August 2024. The mean aqueous PCB concentration was 1.18 ng/L, and the mean TSS concentration was 2.95 mg/L.

Mercury concentrations in clams placed in the K-901-A Pond were again comparable to those of the reference site (0.06 µg/g and 0.03 µg/g, respectively).

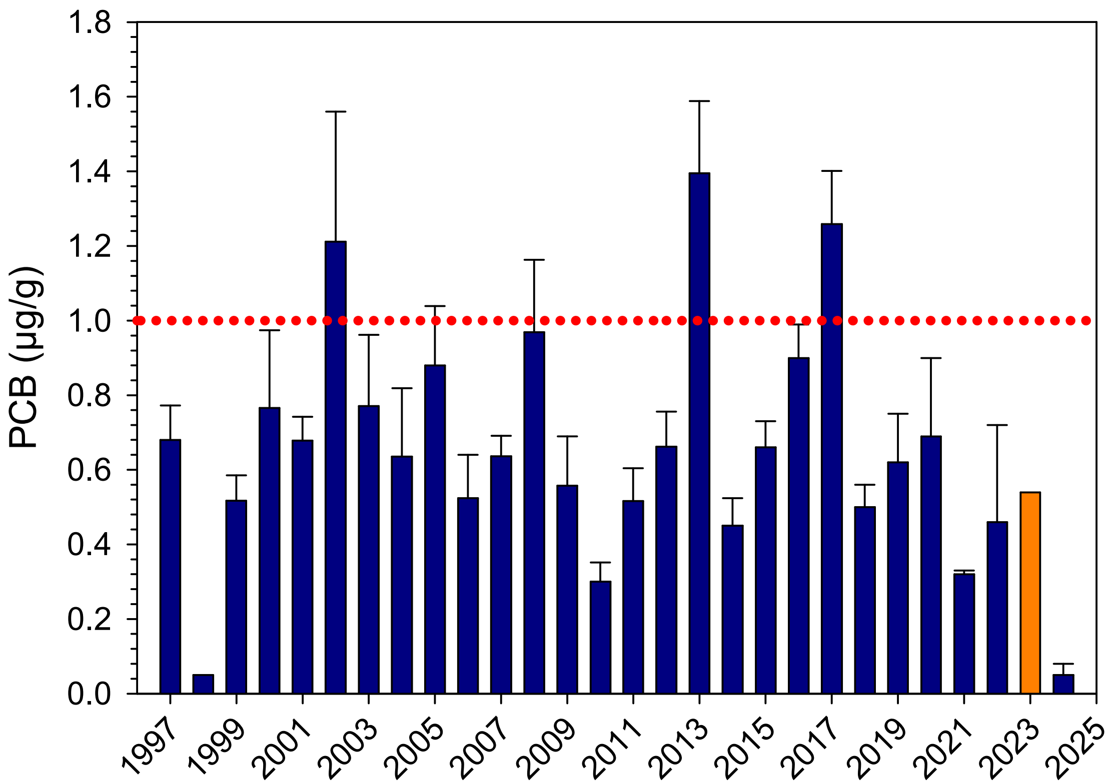


Figure 12. Mean total PCB concentrations (µg/g, wet wt; ±1 standard error) in largemouth bass fillets from the K-901-A Pond, 1993–2024. N = 20 fish per year, when possible. (In 2023, no largemouth bass were encountered, and only one individual carp was collected.) The dotted red line shows the advisory level for PCBs in fish fillets (1 µg/g).

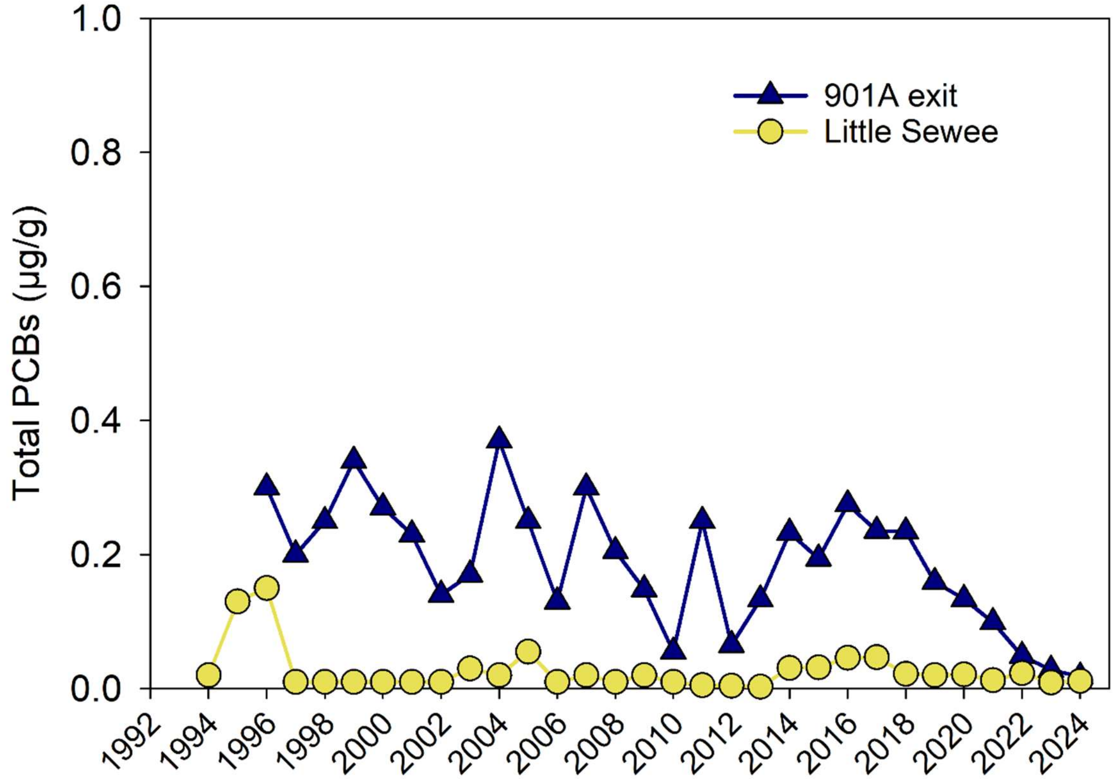


Figure 13. Mean total PCB concentrations (µg/g wet wt) in the soft tissues of caged Asiatic clams deployed in the K-901-A Pond compared with reference stream clams (Little Sewee Creek, shown in yellow), 1993–2024. Total PCBs are defined as the sum of Aroclors 1248, 1254, and 1260. N = 2 composites of 10 clams each per year.

2.4 K-720 SLOUGH

Routine bioaccumulation monitoring in the K-720 Slough began in 2009. Although the target species for fish fillet monitoring in this slough is largemouth bass, as in the K-901-A Pond, it has been difficult to collect a full sample of 20 fish of this species. To complete the collection, common carp were also collected for a total of 19 fish. Figure 14 shows the temporal trends in fish fillet concentrations in the slough. In 2024, PCB concentrations in all monitored fish species were below the state advisory limit of 1 µg/g. In all cases, PCB levels in fish collected from the K-720 Slough were significantly lower than those in the K-901-A Pond for the same species (Figure 11, Table 1). PCB concentrations in largemouth bass collected from the K-720 Slough were significantly lower than those in the other monitored ponds, averaging 0.02 µg/g in 2024 (Figures 11 and 14). Concentrations in carp collected from the slough were higher than concentrations in bass, averaging 0.55 µg/g. Total PCB concentrations in whole-body gizzard shad from the K-720 Slough were similar to those seen in recent years and were lower than those seen in whole-body fish collected from the other monitored ponds, averaging 0.18 µg/g in 2024 (Figure 11; Table 1).

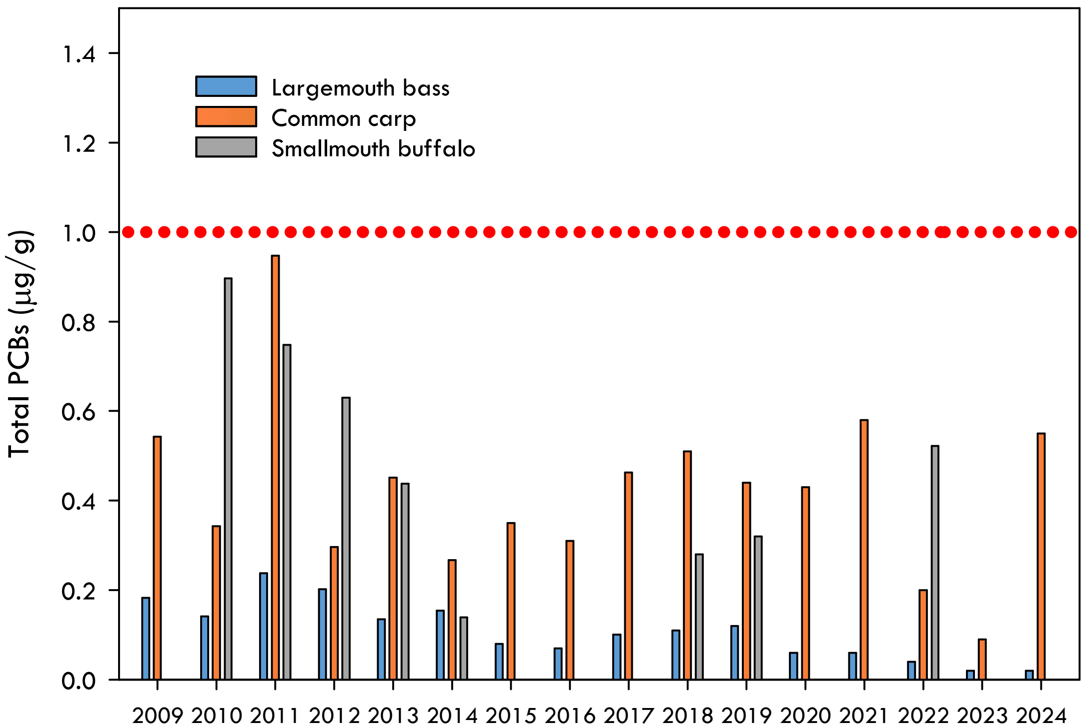


Figure 14. Mean total PCB concentrations (µg/g, wet wt) in the fillets of largemouth bass, common carp, and smallmouth buffalo collected from the K-720 Slough, 2009–2024. Total PCBs are defined as the sum of Aroclors 1248, 1254, and 1260. The target sample was 20 largemouth bass, but because these fish are not abundant in the slough, carp and smallmouth buffalo were also collected to complete the sample size of 20 fish. The dotted red line shows the advisory level for PCBs in fish fillets (1 µg/g).

Table 1. Average concentrations (µg/g, wet wt) of total PCBs (Aroclors 1248, 1254, and 1260) and Hg_T in fillets and whole-body composites of fish collected in 2024 near ETTP. Each whole-body composite sample is composed of 10 individual fish. Also shown are the ranges of values observed for PCBs and the number of fish whose fillet PCB concentrations exceeded PCB targets for the K-1007-P1 Pond out of the total number of fish (or composites) sampled (n) (1 µg/g total PCBs in fish fillets and 2.3 µg/g in whole-body composites).

Site	Species	Sample type	Sample size *(n)*	Total PCBs (mean ± SD)	Range of total PCB values	Number >target[a] (PCBs)/*n*
K-1007-P1 Holding Pond	Bluegill	Fillet	20	0.22 ± 0.09	0.11–0.41	0/20
		Whole-body composite	6	1.00 ± 0.21	0.77–1.31	0/6
K-901-A Holding Pond	Largemouth bass	Fillet	14	0.05± 0.03	0.02–0.04	0/14
	Common carp	Fillet	1	1.69	—	1/1
	Bluegill	Fillet	20	0.08 ± 0.09	0.02–0.42	0/20
		Whole-body composite	6	0.15 ± 0.06	0.09-0.22	0/6
K-720 Slough	Largemouth bass	Fillet	16	0.02 ± 0.01	0.01–0.04	0/16
	Common carp	Fillet	3	0.55 ± 0.09	0.49–0.65	0/3
	Gizzard shad	Whole-body composite	6	0.18 ± 0.01	0.17–0.19	0/6
CRM 11 .0	Bluegill	Whole-body composite	6	0.02 ± 0.01	0.01–0.03	0/6
	Gizzard shad	Whole-body composite	6	0.04 ± 0.005	0.03–0.04	0/6
PCM 1.0	Bluegill	Whole-body composite	6	0.08 ± 0.02	0.05–0.10	0/6
	Gizzard shad	Whole-body composite	6	0.13 ± 0.02	0.11–0.17	0/6

Notes: SD = standard deviation, *n* = number; CRM = Clinch River mile; PCM = Poplar Creek mile.

2.5 POPLAR CREEK AND OFF-SITE

Long-term PCB monitoring trends in catfish collected from Poplar Creek, the Clinch River (CRM 20 and CRM 11), and the Tennessee River (Tennessee River mile 531) were presented in the FY 2023 Remediation Effectiveness Report and are shown in Figure 15. Figure 15 shows the effect of upstream Hg sources in Poplar Creek and downstream dilution on bioaccumulation in sunfish. Mercury levels in fish collected in fall 2022 remained elevated in the lower EFPC, upper Poplar Creek, and Mitchell Branch, but levels decreased in response to downstream dilution of Mitchell Branch into Poplar Creek and Poplar Creek into the Clinch River. Concentrations were at or below the EPA AWQC at all sites monitored off-site.

Mean total PCB concentrations in catfish from all four sites have decreased significantly in recent years relative to concentrations observed during the 1980s and 1990s, although substantial year-to-year variability is present. In 2024, in addition to catfish fillets, bluegill and gizzard shad were collected for whole-body analysis for comparison of the whole-body fish collected at the ETTP ponds (Table 1). PCB concentrations at these off-site locations were lower than those in fish of the same species collected in the K-1007-P1 Pond and the K-901-A Pond but were comparable to those collected in the K-720 Slough.

In contrast to the continuous record of same-species fish monitoring for PCBs, long-term Hg trending in Poplar Creek has been more sporadic. Mercury has been monitored at several locations in Poplar Creek, largely to assess the effects of Hg discharges from EFPC into Poplar Creek and the Clinch River. Poplar Creek kilometer (PCK) 8.2 is at the confluence of EFPC and Poplar Creek, PCK 6.9 is just downstream of the confluence of Mitchell Branch, and PCK 1.6 is just downstream of where the K-1007-P1 Pond exchanges with Poplar Creek. Mercury was measured annually in bluegill sunfish from 1987 to 1994 at PCK 8.2, PCK 6.9, and, for several years during that time, PCK 1.6 (Figure 16). During the time shown in Figure 16, Hg concentrations in bluegill fillets exceeded the EPA AWQC of 0.3 µg/g at the upstream Poplar Creek sites (PCKs 8.2 and 6.9). No significant difference in Hg concentrations was observed between these two sites in any year, suggesting either that these sites are not far enough from each other to show a significant dilution effect or that the Hg input from Mitchell Branch during this period was enough to compensate for the downstream dilution between the sites. Indeed, Hg concentrations in redbreast sunfish in Mitchell Branch increased during this same period (Figure 5, top). Mercury concentrations in fish collected from PCK 1.6 were significantly lower than those at the upstream Poplar Creek sites because of downstream dilution. Mercury concentrations in fish from PCK 1.6 increased significantly from 1987 and 1988 to 1993 and 1994, and they exceeded the EPA AWQC in 1994.

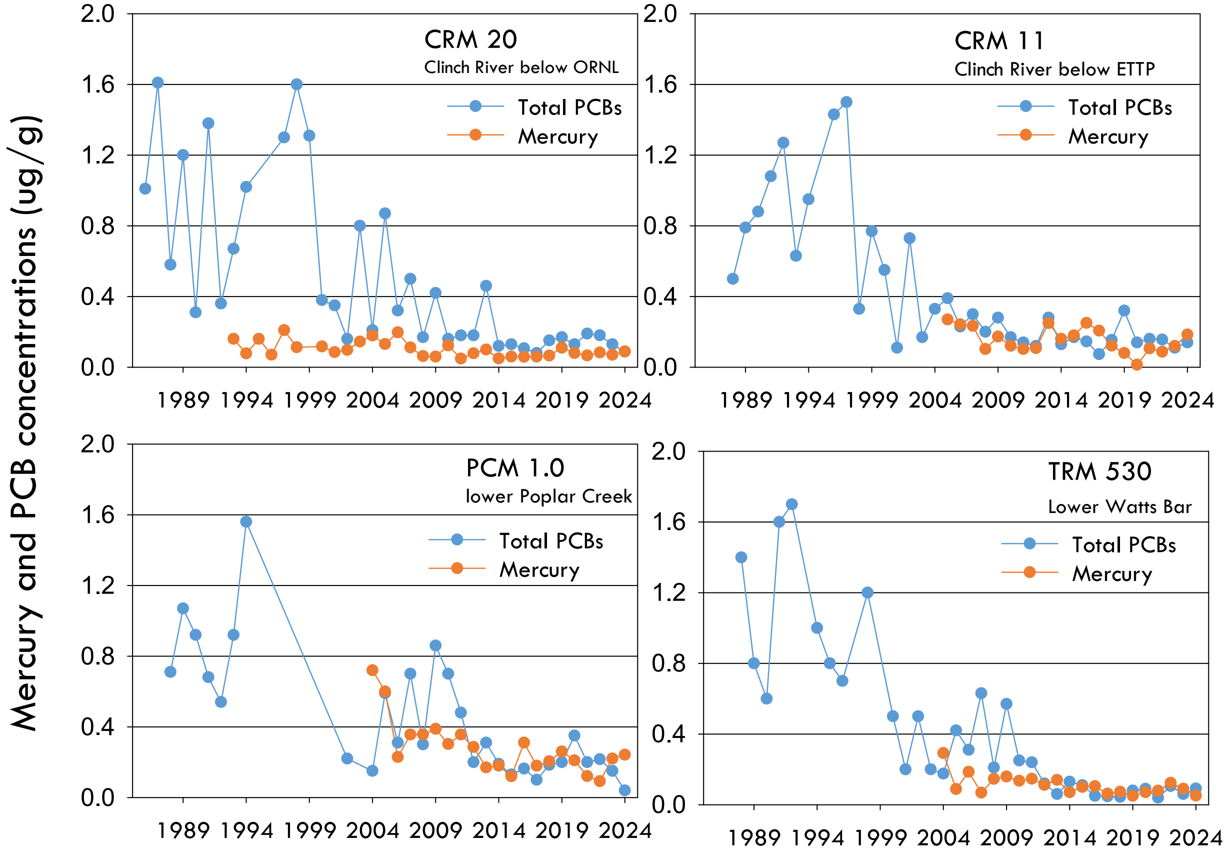


Figure 15. Average PCB and Hg concentrations (µg/g, wet wt) in channel catfish from the Clinch River, Poplar Creek, and Tennessee River, 1986–2024.

Data points represent mean concentrations of total PCBs, defined as the sum of Aroclors 1248, 1254, and 1260, n = 6. Information courtesy of multiple programs, including the BMAP, Annual Site Environmental Report, Tennessee Valley Authority, and the WRRP. (PCM = Poplar Creek mile; TRM = Tennessee River mile.)

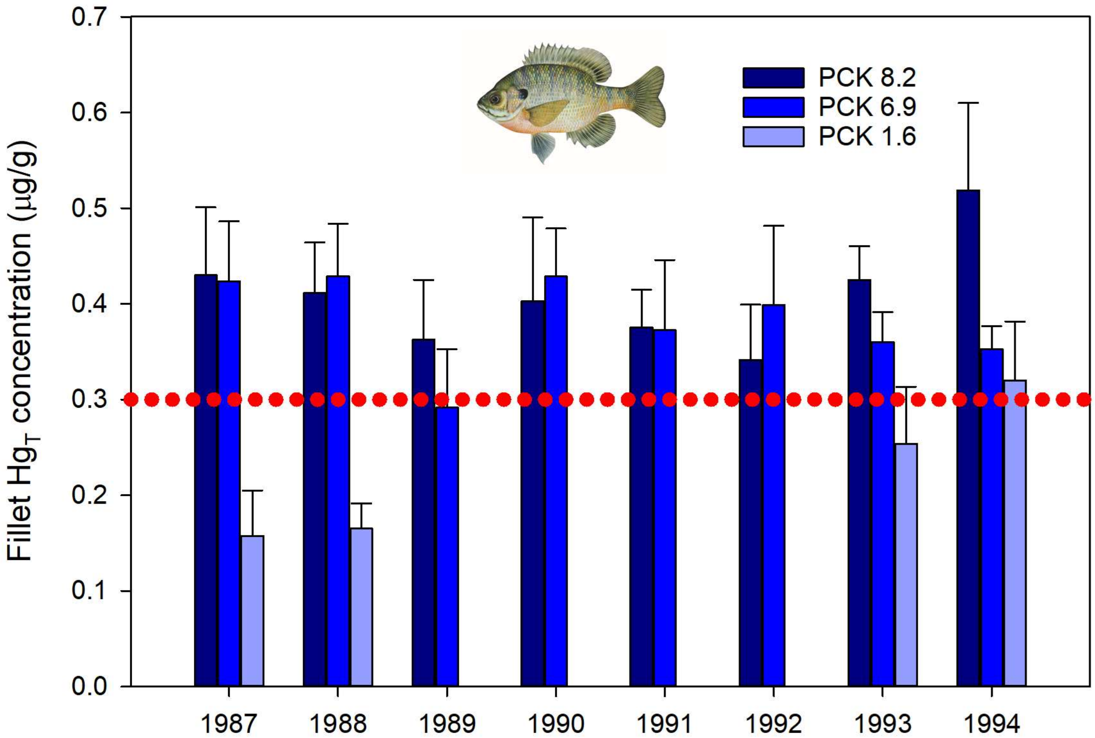


Figure 16. Total Hg concentrations (µg/g, wet wt; ±1 standard error) in bluegill sunfish fillets collected in Poplar Creek, 1987–1994. Bars represent the mean of six samples. The red dotted line shows the EPA-recommended AWQC for Hg in fish fillets (0.3 µg/g).

Since 2006, bluegill have been collected from PCK 1.6, but this species is no longer encountered at PCK 8.2; redbreast sunfish are now collected at this site. Mercury concentrations in redbreast sunfish from PCK 8.2 have been significantly higher than the concentrations in bluegill sunfish from PCK 1.6 (Figure 17). These concentrations are consistent with the spatial patterns observed in earlier years and reflect the downstream dilution of Hg in Poplar Creek, as well as interspecies differences. Previous studies have shown that redbreast sunfish accumulate 25%–50% more Hg than similarly sized bluegill sunfish collected from the same sites (Southworth et al. 1994). In 2006, fillet Hg concentrations at PCK 8.2 were comparable to the bluegill concentrations from this site in the late 1980s, suggesting that Hg exposure decreased from the 1980s to the mid-2000s. The mean Hg concentration in redbreast sunfish collected from PCK 8.2 in 2024 was 0.58 µg/g. Mercury concentrations in bluegill at PCK 1.6 were below the EPA AWQC in 2024 (Figure 17).

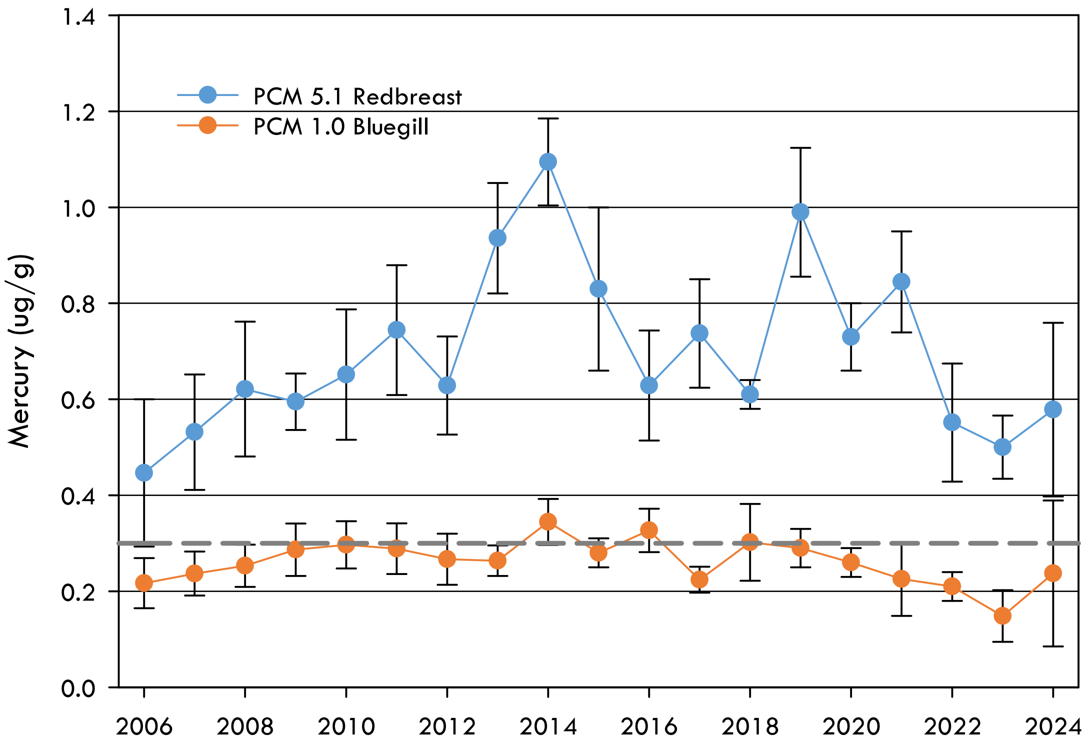


Figure 17. Total Hg concentrations (µg/g, wet wt; ±1 standard error) in the fillets of sunfish collected in Poplar Creek, 2006–2024. Points represent the mean of six samples. The gray dotted line shows the EPA-recommended AWQC for Hg in fish fillets (0.3 µg/g).

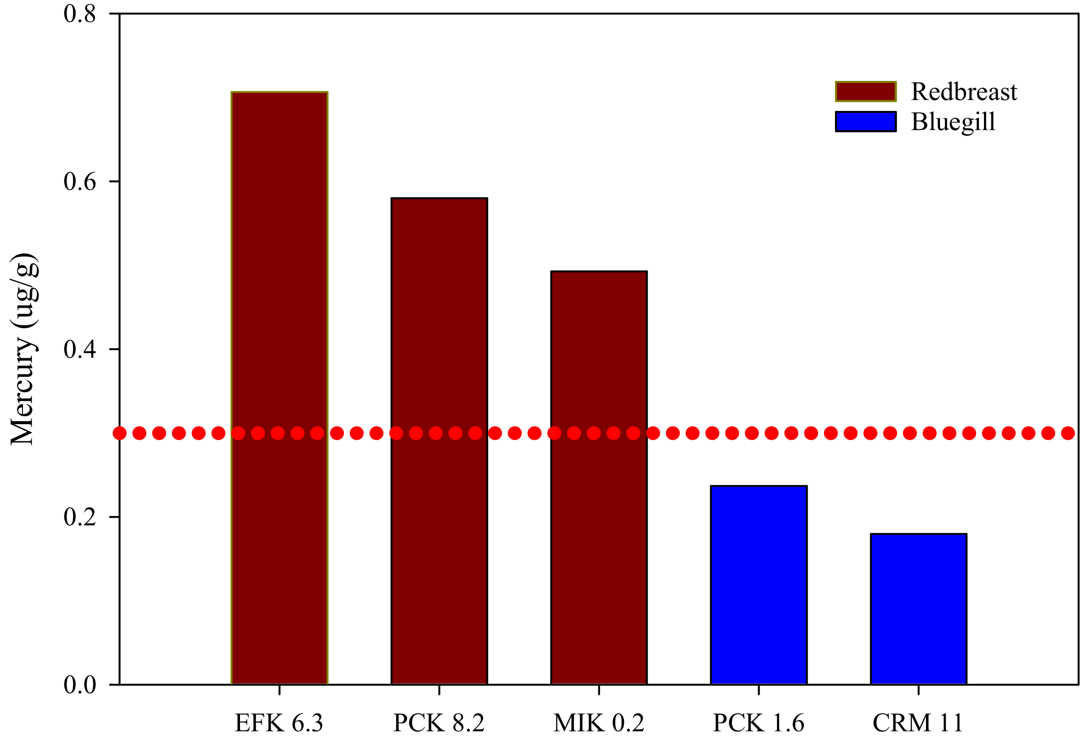


Figure 18. Spatial trends in Hg concentrations (µg/g, wet wt) in the fillets of sunfish collected around Poplar Creek, FY 2024. The red bars represent mean Hg_T concentration in redbreast sunfish, and blue bars represent those in bluegill sunfish, n = 6. The red dotted line shows the EPA-recommended AWQC for Hg in fish fillets (0.3 µg/g). (EFK = EFPC kilometer.)

3. TASK 2: INSTREAM BENTHIC MACROINVERTEBRATE COMMUNITY MONITORING

The major objectives of the benthic macroinvertebrate task are to (1) help assess the ecological condition of Mitchell Branch and (2) evaluate changes in stream ecology associated with changes in facilities operations and remedial actions within the Mitchell Branch watershed. To meet these objectives, the condition of the benthic macroinvertebrate community of Mitchell Branch has been monitored routinely since late 1986. This summary includes the results from samples collected each April from 1987 to 2024 following ORNL BMAP quantitative sampling protocols (Figure 19), as well as those from samples collected annually (August/September) from 2008 to 2024 with TDEC semi-quantitative sampling protocols for estimating the Tennessee Macroinvertebrate Index (TMI) and the habitat score (Tennessee Department of Environment and Conservation 2021).

Figure 19. Collecting an invertebrate sample using ORNL BMAP protocols.

For both sets of protocols, four sites were assessed in Mitchell Branch: MIKs 0.4, 0.7, 0.8, and 1.4. MIK 1.4 serves as the primary reference site, but narrative scores derived using TDEC protocols are based on reference conditions established by TDEC from a suite of reference sites in the same ecoregion as Mitchell Branch. Finally, this summary also includes a comparison between the macroinvertebrate community structure at the four Mitchell Branch sites and five reference sites on the ORR. Most of these reference sites—spanning a range of stream sizes both smaller and larger than Mitchell Branch (based on watershed area)—have been monitored using ORNL protocols since the mid-1980s for other biological monitoring projects on the ORR (ORNL BMAP and WRRP/Bear Creek Biological Monitoring Program) (Table 2). This summary provides information regarding how the invertebrate community structure at Mitchell Branch sites, including MIK 1.4, compares with the community structure of a range of relatively unaffected reference sites on the ORR.

Table 2. Stream sites included in the comparison between Mitchell Branch and other reference sites on the ORR.

Site	Location		Watershed area (km^2)	Program
	Latitude (N)	Longitude (W)		
Mitchell Branch				
MIK 0.4	35.93859	84.39040	1.554	ETTP BMAP
MIK 0.7	35.93786	84.38792	1.347	ETTP BMAP
MIK 0.8	35.93786	84.38682	1.269	ETTP BMAP
MIK 1.4 (reference)	35.93790	84.37662	0.311	ETTP BMAP
Other ORR reference sites				
First Creek kilometer 0.8	35.92671	84.32327	0.596	ORNL BMAP
Fifth Creek kilometer 1.0	35.93251	84.31741	0.596	ORNL BMAP
Gum Hollow Branch kilometer 2.9	35.96385	84.31594	0.777	Bear Creek BMAP/WRRP
Walker Branch kilometer 1.0	35.95805	84.27953	1.010	ORNL BMAP
White Oak Creek kilometer 6.8	35.94106	84.30145	2.072	ORNL BMAP

3.1 MITCHELL BRANCH—ORNL AND TDEC PROTOCOLS

In comparing values from April 2024 to those in April 2023, total taxonomic richness (i.e., the total number of taxa per sample) increased at all sites except MIK 0.4 and Ephemeroptera, Plecoptera, and Trichoptera (EPT; mayflies, stoneflies, and caddisflies, respectively) taxonomic richness—that is, the total number of pollution-intolerant EPT taxa per sample—increased only at MIK 0.8, and no sites showed significant decreases in either total or EPT taxonomic richness values (Figure 20). Both richness metric values were lowest at MIK 0.4 and highest at MIK 0.8, though values at the three upstream sites were all more similar to each other than to MIK 0.4 (Figure 20). The EPT taxonomic richness at MIK 0.8 showed a second consecutive year of increased values, reaching levels not seen there since 2016 (Figure 20).

The percent density of pollution-intolerant taxa (higher values are indicative of better conditions) was highest at MIK 1.4, the reference site, and lowest at MIK 0.4 in 2024—a trend that has been observed over most of the time series (Figure 21). The percent density of pollution-tolerant taxa (lower values are indicative of better conditions) in 2024 was lowest at MIK 1.4 and highest at MIK 0.7 and MIK 0.4 (Figure 21). In 2024, the percent density of pollution-tolerant taxa at MIK 1.4 was closer to but slightly above levels typically observed over the monitoring period (Figure 21). These results suggest that the invertebrate community in Mitchell Branch continues to be mildly to moderately degraded downstream of MIK 1.4.

Based on TDEC 2021 protocols, scores for the TMI in 2024 rated the invertebrate community at MIK 1.4 as passing biocriteria guidelines, whereas the communities in the three lower Mitchell Branch sites scored as falling below biocriteria guidelines (Figure 22, Table 3). From 2023 to 2024, TMI scores decreased at all sites except MIK 0.4, where the score increased. The decreased scores at the three upper MIK sites in 2024 reflect decreases in several different biocriteria, including the Taxonomic Richness Score (MIK 0.8), the EPT Richness Score (MIK 0.7 and MIK 0.8), the EPT Percent Abundance Score (MIK 0.7), and the Clinger Percent Abundance Score (MIK 1.4). The increased score at MIK 0.4 was due to increases in both the EPT Richness and North Carolina Biotic Index scores, indicating that more pollution-intolerant species were present (Table 3). The TDEC protocol states that TMI scores should be calculated only for samples with 160–240 invertebrates identified to genus (Tennessee Department of Environment and Conservation 2021). In 2024, samples at MIK 0.7 and MIK 0.8 fell below this threshold (Figure 22), indicating results should be interpreted with caution.

Based on TDEC stream habitat protocols, habitat quality was found to be above the ecoregion 67f guideline at all four sites in Mitchell Branch (Figure 22). Habitat scores remained similar (MIK 0.7 and MIK 0.8) or decreased (MIK 0.4 and MIK 1.4) in 2024 while remaining above the habitat quality threshold over the past four years (Figure 22). In general, these decreases were driven by increased sediment deposition, embeddedness of riffles, bank stability, and bank vegetation protection issues (Figure 23). Small riparian width, particularly on the left bank, remains an issue at all sites except MIK 1.4. Habitat conditions related to riffle stability (i.e., frequency of reoxygenation zones) and channel flow improved or remained constant at all sites.

Mitchell Branch is listed as an impaired waterbody (Tennessee Department of Environment and Conservation 2022) for fish and aquatic life, physical substrate and habitat alterations being the cause for impairment. Despite some improvements during the monitoring period, Mitchell Branch continues to be a degraded system, as indicated by the low TDEC TMI scores at the three downstream sites. In particular, the lack of suitable habitat for EPT taxa continues to negatively affect sites in Mitchell Branch.

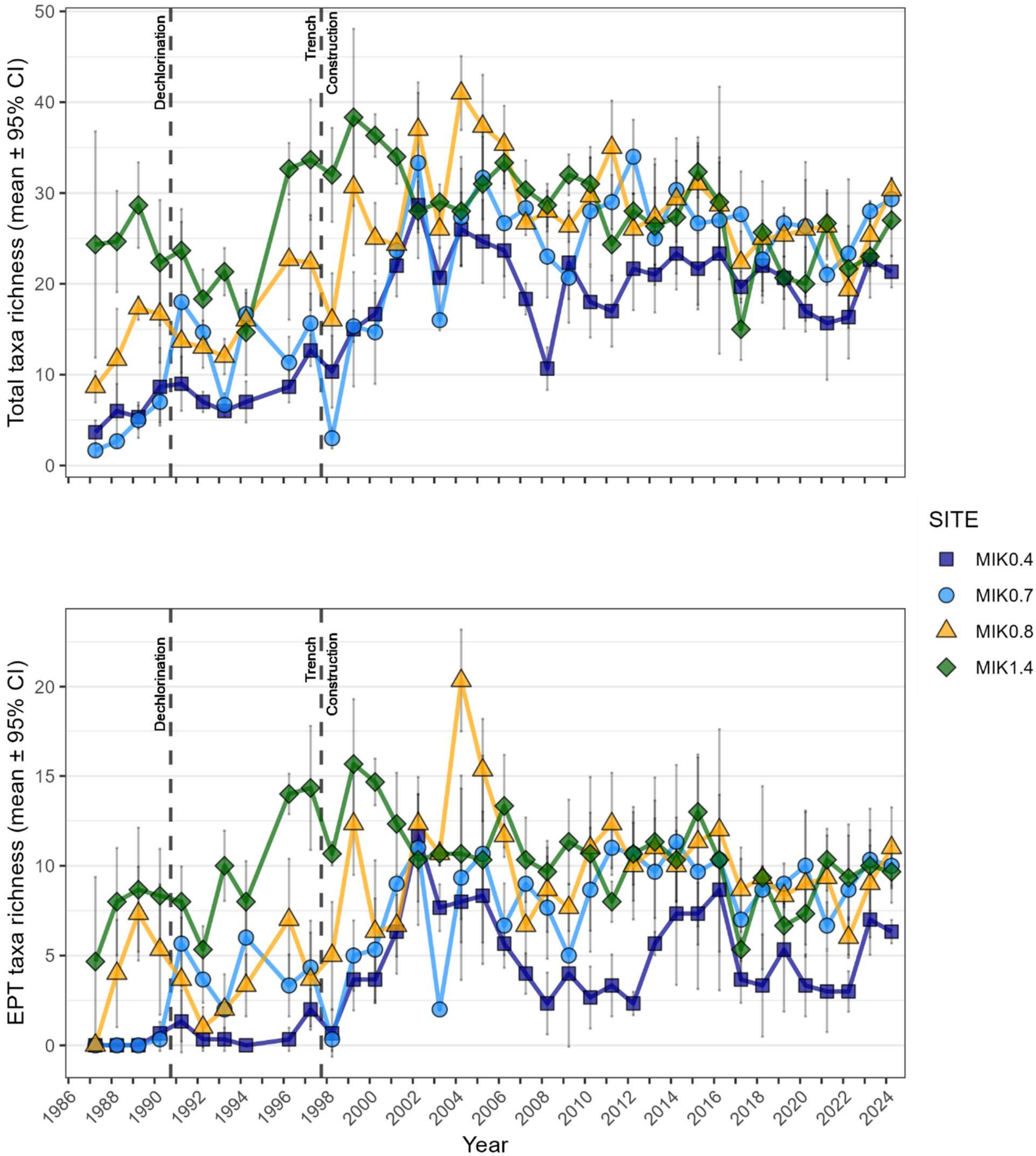


Figure 20. Mean total taxonomic richness and taxonomic richness of the pollution-intolerant EPT taxa (mayflies, stoneflies, and caddisflies; bottom) for the benthic macroinvertebrate communities at sites in Mitchell Branch, April 1987–2024, collected using ORNL protocols. Samples were not collected in April 1995. (MIK 1.4 is the upstream reference site.)

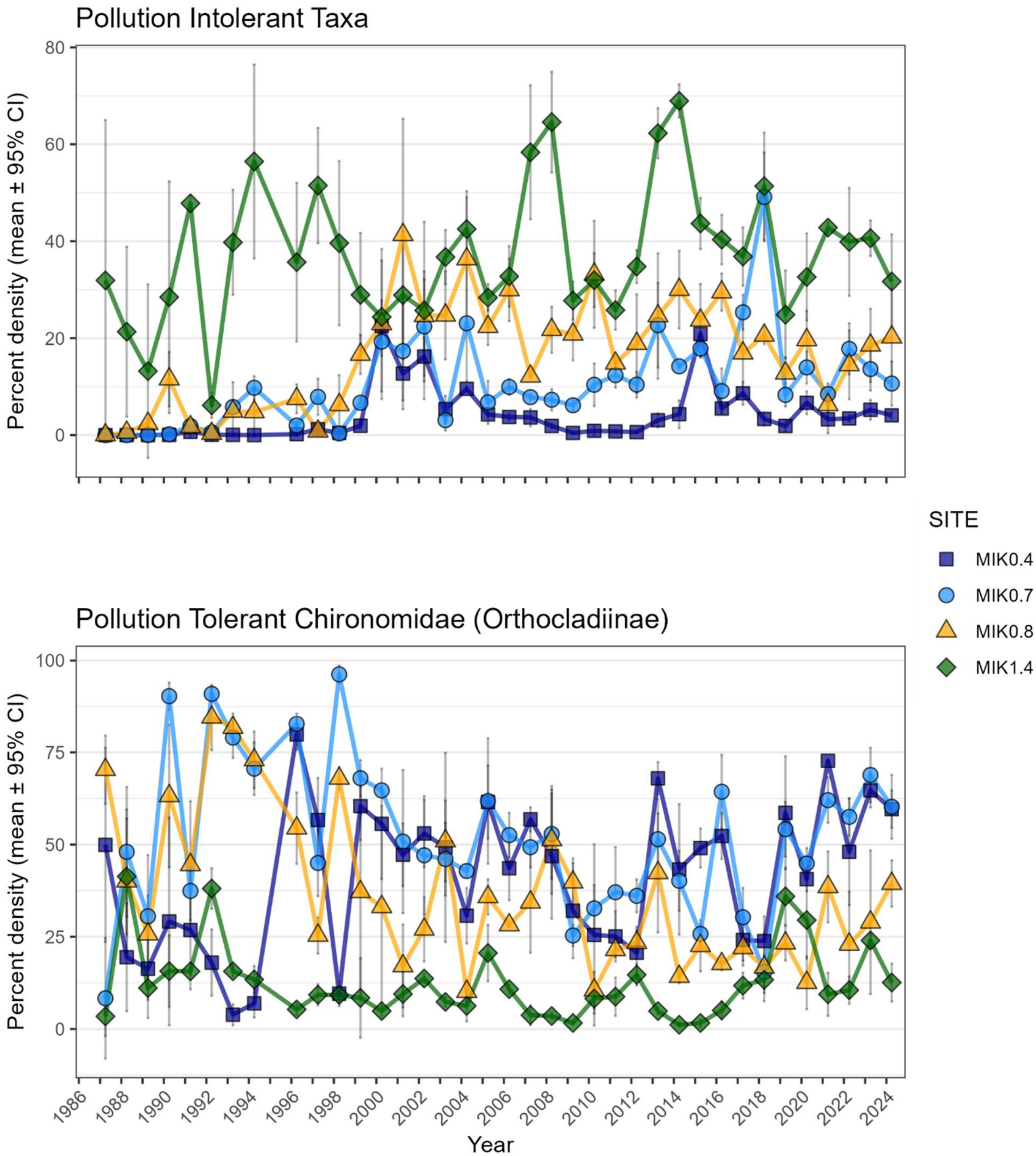


Figure 21. Mean percent density of the pollution-intolerant EPT taxa (stoneflies, mayflies, and caddisflies; top) and that of the pollution-tolerant Orthocladiinae midge larvae (Chironomidae; bottom) at sites in Mitchell Branch, April 1987–2024, collected using ORNL protocols. Percentages are based on total densities for each site. Samples were not collected in April 1995. (MIK 1.4 is the upstream reference site.)

Table 3. Tennessee Macroinvertebrate Index (TMI) metric values and scores, index score, and narrative ratings for Mitchell Branch, August 6, 2024.[a,b]

Site[c]	Metric values							Metric scores							TMI[d]
	Taxa rich	EPT rich	%EPT	%OC	NCBI	%Cling	%TN Nuttol	Taxa rich	EPT rich	%EPT	%OC	NCBI	%Cling	%TN Nuttol	
MIK 0.4	17	4	10.6	1.9	4.5	76.0	36.5	2	2	0	6	6	6	4	26
MIK 0.7	12	3	10.3	10.3	5.8	46.2	41.0	2	0	0	6	4	4	4	20[e]
MIK 0.8	12	2	25.0	14.3	5.3	73.2	44.6	2	0	2	6	4	6	4	24[e]
MIK 1.4	25	9	40.2	8.9	4.4	51.4	41.6	4	4	4	6	6	4	4	32

[a]TMI metric calculations and scoring, index calculation, and narrative ratings are based on TDEC protocols for Ecoregion 67f (Tennessee Department of Environment and Conservation 2021).
[b]Taxa rich = Taxa richness; EPT rich = mayflies, stoneflies, and caddisflies taxa richness; %EPT = EPT percent abundance excluding *Cheumatopsyche* spp.; %OC = percent abundance of oligochaetes (worms) and chironomids (nonbiting midges); NCBI = North Carolina Biotic Index; %Cling = percent abundance of taxa that build fixed retreats or otherwise attach to substrate surfaces in flowing water; %TN Nuttol = percent abundance of nutrient-tolerant organisms.
[c]Watershed/drainage areas are provided in Table 2.
[d]TMI = TMI score. TMI is the total index score, and higher index scores indicate higher quality conditions. A score of ≥32 is considered as passing biocriteria guidelines (green shading). TMI scores <32 are indicated by yellow shading.
[e]TDEC protocol states that TMI scores should be calculated only for samples with 160 to 240 invertebrates identified to genus. In August 2024, only 39 individuals were collected from MIK 0.7 and 56 individuals from MIK 0.8, so results from these sites should be interpreted with caution.

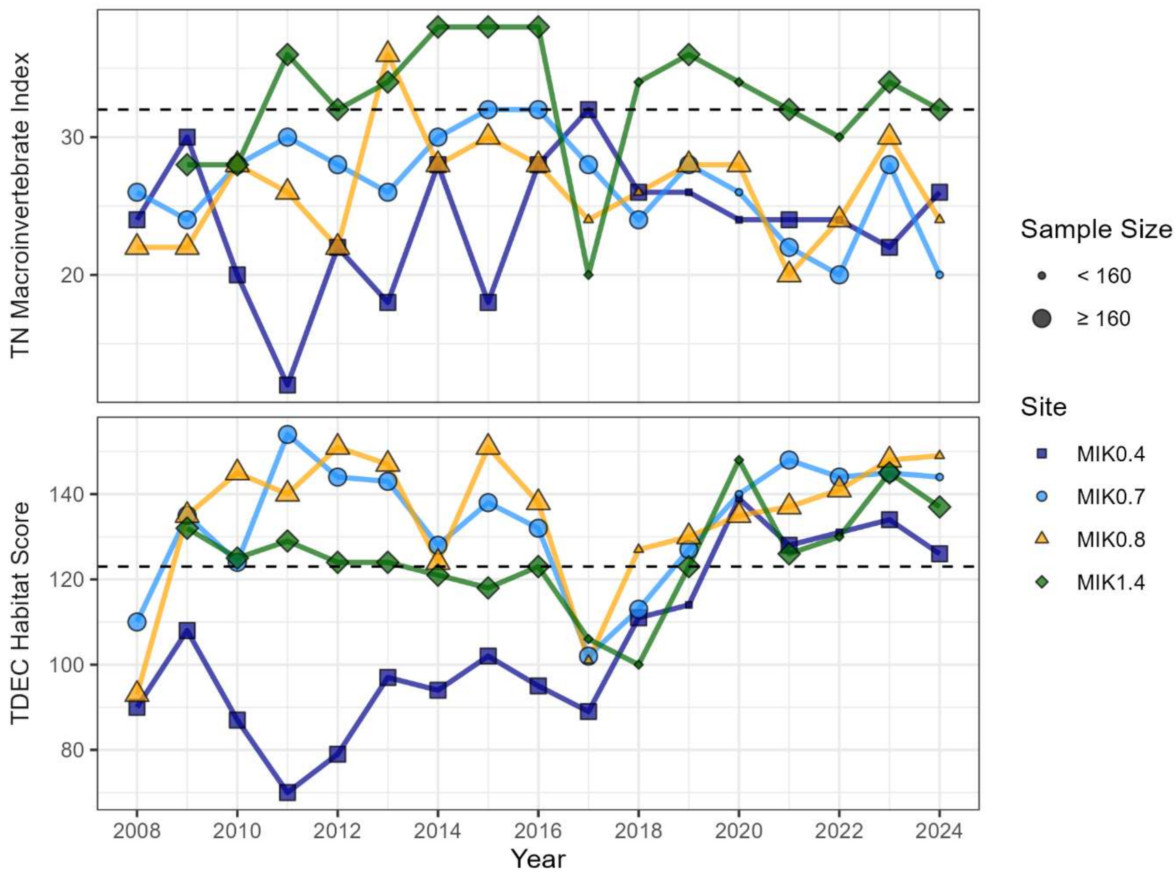


Figure 22. Temporal trends in the TDEC Macroinvertebrate Index (top) and the TDEC habitat scores (bottom) for sites in Mitchell Branch, August 2008–2024. MIK 1.4 was not sampled with TDEC protocols in 2008. The dashed horizontal line on each graph shows the rating threshold for each index based on biocriteria and ecoregion 67f guidelines, respectively; values at or above the threshold represent passing scores, whereas those below do not. Samples that exceeded or failed to meet the minimum number of invertebrates are indicated by large or small point sizes, respectively.

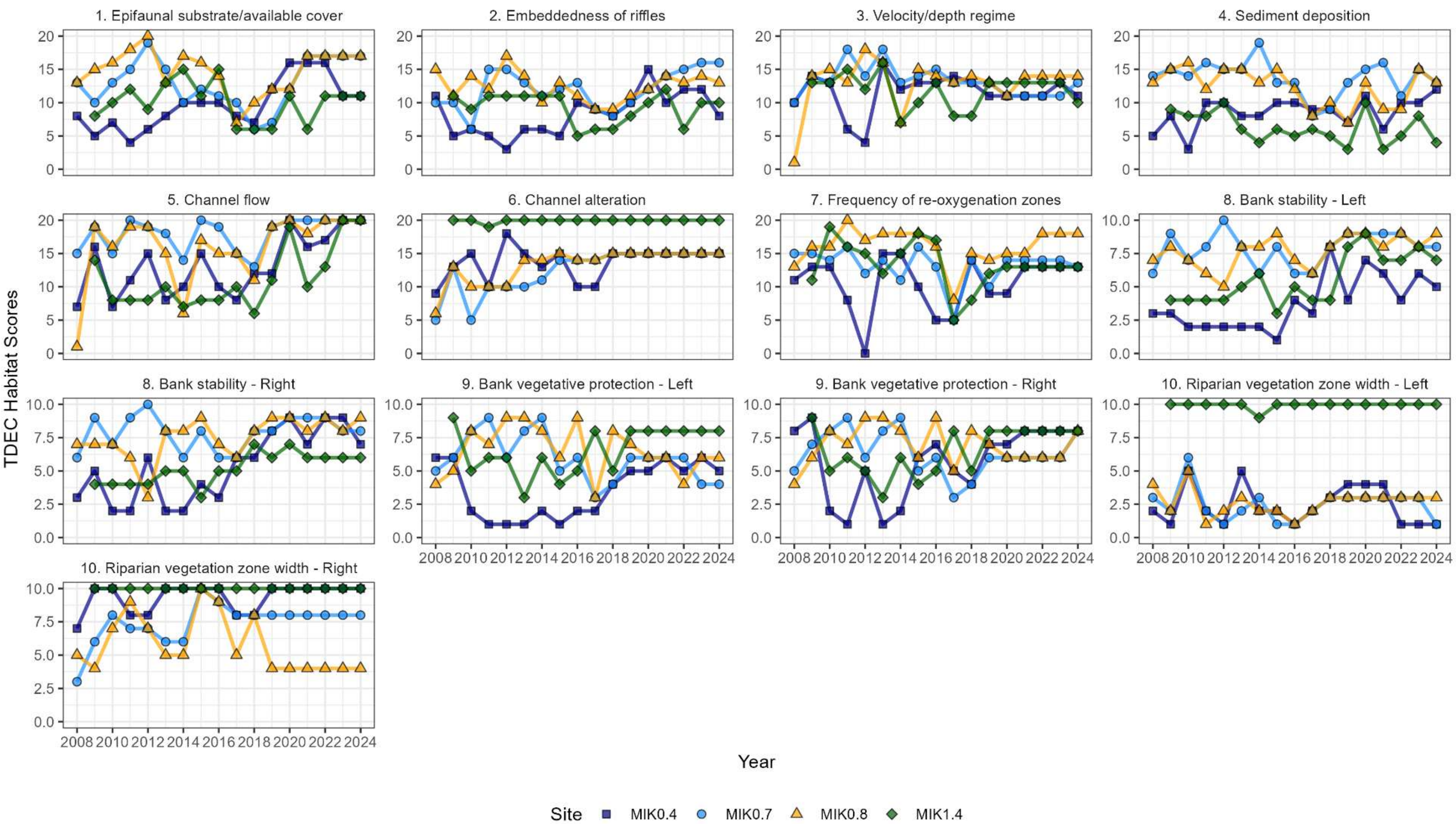


Figure 23. Temporal trends in components that comprise the TDEC habitat scores for sites in Mitchell Branch, August 2008–2024. Scores in each category labeled 1 to 10 range from zero (poor score) to 20 (optimal score); scores for categories 8 (bank stability), 9 (bank vegetative protection), and 10 (riparian vegetative zone width) are given for each bank (left and right), and thus each bank is scored on a scale from 0 to 10. MIK 1.4 was not sampled with TDEC protocols in 2008.

3.2 COMPARISON BETWEEN MITCHELL BRANCH AND OTHER REFERENCE SITES ON THE ORR

The benthic macroinvertebrate communities in Mitchell Branch were compared with those of ORR reference streams over a 19-year period, since 2005. Specifically, in Figures 24 and 25, mean values (±95% confidence intervals) for total taxonomic richness and taxonomic richness of pollution-intolerant taxa, and for percentage densities of pollution-tolerant and pollution-intolerant taxa for Mitchell Branch, were compared with the 95% confidence interval of five reference sites, shown in gray shading: First Creek kilometer (FCK) 0.8, Fifth Creek kilometer (FFK) 1.0, White Oak Creek kilometer (WCK) 6.8, Walker Branch kilometer (WBK) 1.0, and Gum Hollow Branch kilometer (GHK) 2.9.

The total taxonomic richness at MIK 0.4 and MIK 1.4 and the taxonomic richness of pollution-intolerant (EPT) taxa at all Mitchell Branch sites fell below the 95% confidence interval of the ORR reference sites in 2024 (Figure 24). Although the overall pattern for EPT taxonomic richness remains similar to that generally seen throughout the time series, the 95% confidence interval for total taxonomic richness at the reference sites has shifted down over the course of the time series since the mid/late 2000s, though pollution-tolerant taxa may have comprised most of those lost over this time period (Figure 24).

In contrast to richness metrics, the mean percent densities of pollution-intolerant and pollution-tolerant taxa at MIK 1.4 were not often outside of the range for the reference sites prior to 2019 and 2020 but were similar to those of ORR reference sites in 2021 and 2022; however, the mean percent density of pollution-tolerant taxa was again higher at MIK 1.4 than the reference sites (Figure 25). Since 2005, the mean percent densities of pollution-intolerant and pollution-tolerant taxa at all other MIK sites have been outside the 95% confidence interval for ORR reference sites, with few exceptions.

These results from the comparison of Mitchell Branch sites with ORR reference sites, combined with the long-term results for all Mitchell Branch sites discussed in Section 3.1, suggest that from the standpoint of reference sites, the Mitchell Branch reference site (MIK 1.4) has generally fallen either within or below expected reference conditions on the ORR (depending on the macroinvertebrate metric examined). Furthermore, after a brief excursion in 2019 and 2020, MIK 1.4 has once again fallen outside the 95% confidence interval of the mean percent densities of pollution-intolerant and pollution-tolerant taxa at ORR reference sites in 2024. Factors potentially contributing to excursions of invertebrate community metrics outside of the range of other reference sites include the somewhat smaller size of MIK 1.4 compared with the other reference sites (based on watershed area; Table 2), which may limit the variety of invertebrate species that can colonize and thrive at the site, as well as habitat characteristics that have typically contributed to the lower quality habitat at the site, such as low flow and poor substrate quality (see results in Section 3.1 for the TDEC Habitat Index, Figures 22 and 23).

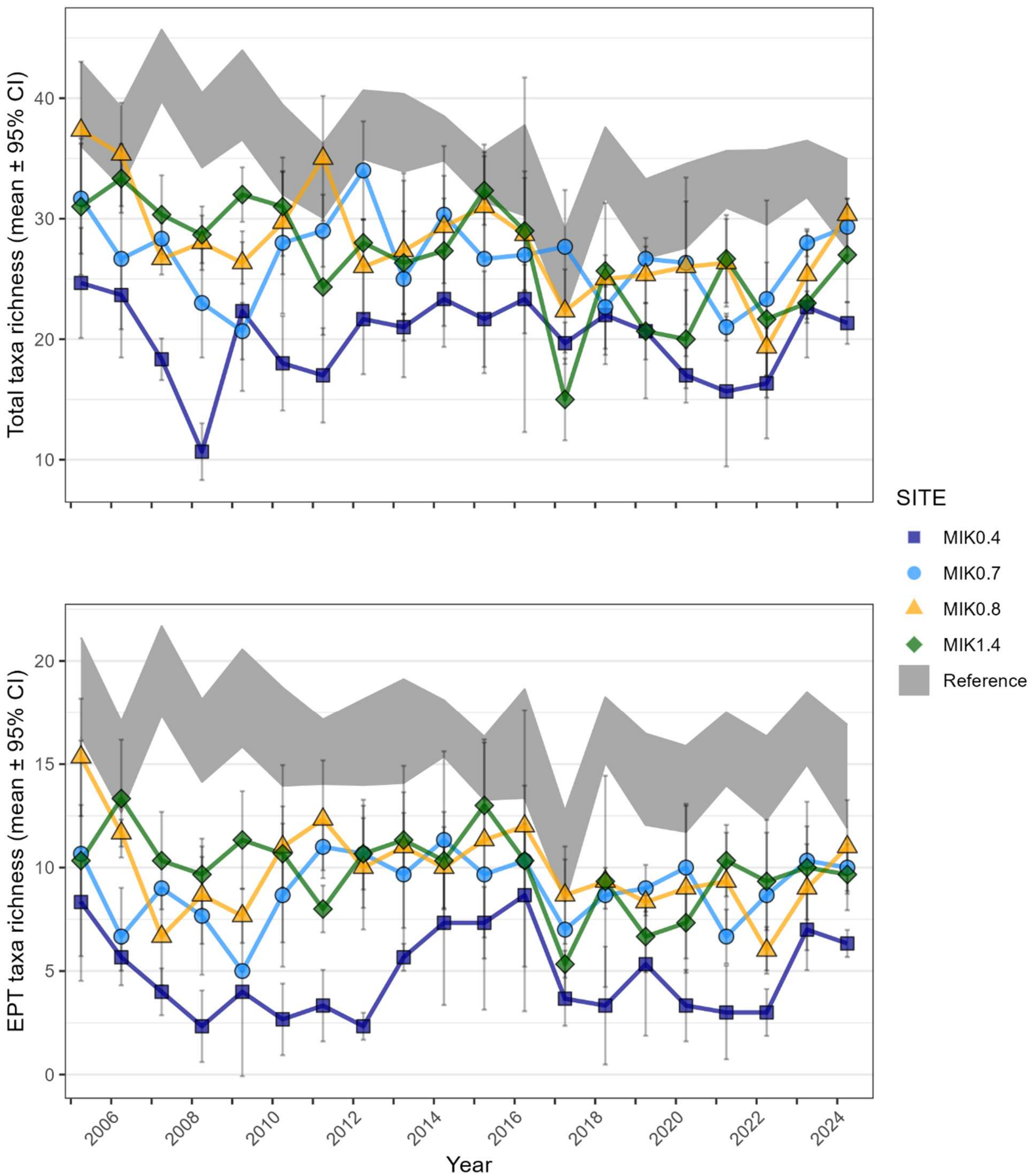


Figure 24. Mean total taxonomic richness (top) and taxonomic richness of the pollution-intolerant EPT taxa (mayflies, stoneflies, and caddisflies; bottom) for the benthic macroinvertebrate communities at sites in Mitchell Branch, April 2005–2024, collected using ORNL protocols. The gray shading on each graph shows the 95% confidence interval (CI) of five additional reference stream sites on the ORR from 2005 to 2024. Reference streams include FCK 0.8, FFK 1.0, GHK 2.9, and WBK 1.0, and WCK 6.8.

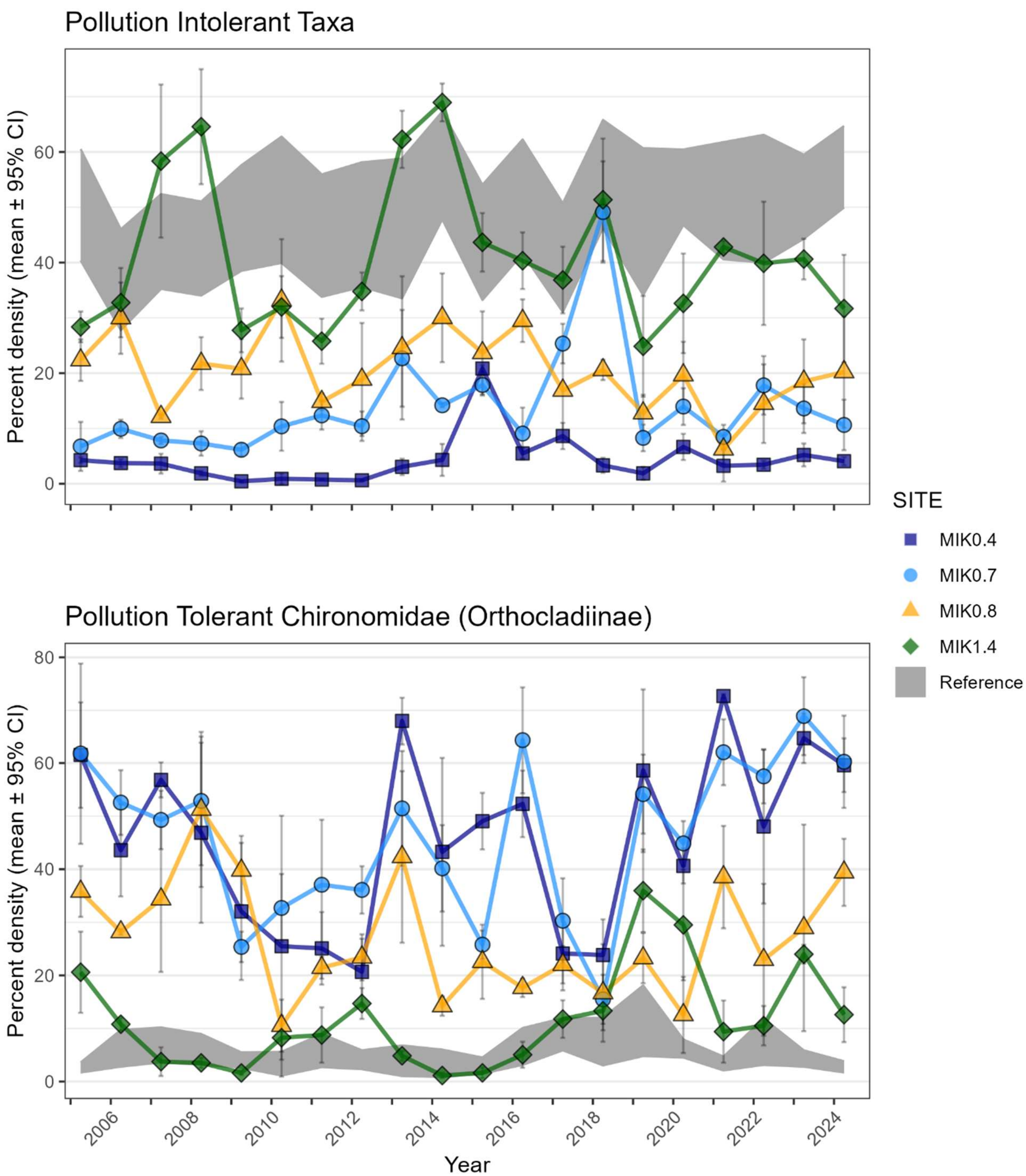


Figure 25. Mean percent densities of the pollution-intolerant taxa (i.e., stoneflies, mayflies, and caddisflies; top), and of the pollution-tolerant Orthocladiinae midge larvae (Chironomidae; bottom) at sites in Mitchell Branch, April 2005–2024, collected using ORNL protocols. Percentages were based on total densities for each site. The gray shading on each graph shows the 95% confidence interval (CI) of five additional reference stream sites on the ORR from 2005 to 2024. Reference streams include FCK 0.8, FFK 1.0, GHK 2.9, and WBK 1.0, and WCK 6.8.

4. TASK 3: FISH COMMUNITY MONITORING

4.1 MITCHELL BRANCH

Fish population and community studies are used to evaluate the biotic integrity (or general ecological health) of Mitchell Branch. The fish community is sampled quantitatively at two sites in Mitchell Branch (Figure 2)—MIK 0.4 (downstream of SD190) and 0.7 (downstream of SD170)—and at local reference streams.

The fish community in Mitchell Branch was most severely impacted in the late 1980s and early 1990s. After some recovery in the mid-1990s, Mitchell Branch was negatively impacted again in 1998 as a result of a remedial activity that replaced a large section of stream bottom with a liner and interlocking rock substrate (Figure 26). In recent years, this reach of stream has shown signs of developing more natural habitat, including a more robust riparian plant community and some instream riffle/pool sequences, as substrate is slowly beginning to accumulate throughout the reach. Since 2000, the fish community has had relatively stable species diversity but rather large variations in fish density and biomass (weight; Figures 27–29), which are often reflective of unstable, impaired streams. Streams with high density and biomass of tolerant fish species are often indicative of either high nutrient influences on a fish community (i.e., more algal growth means more food at the base of the food chain) or poor instream habitat—and often a combination of both. Of the two sites sampled for fish community, MIK 0.7 has experienced the greatest fluctuations in these community parameters, which is likely because of the modified riparian areas and poor instream habitat associated with the remediation work in this reach. Similar conditions are seen in other streams on the ORR, including sections of EFPC where tolerant species dominate the concrete- and bedrock-lined channel, which supports little riparian protection. Streams with limited habitat or habitat that is unstable or still developing are more susceptible to environmental impacts from both natural and anthropogenic sources. Extremely low precipitation in the summer of 2016 is an example and explains the decrease in density and biomass numbers the following year and the recovery in years since.

Figure 26. Construction of lined section of Mitchell Branch, MIK 0.7, in 1998 (top), and more recent habitat conditions in 2024 (bottom).

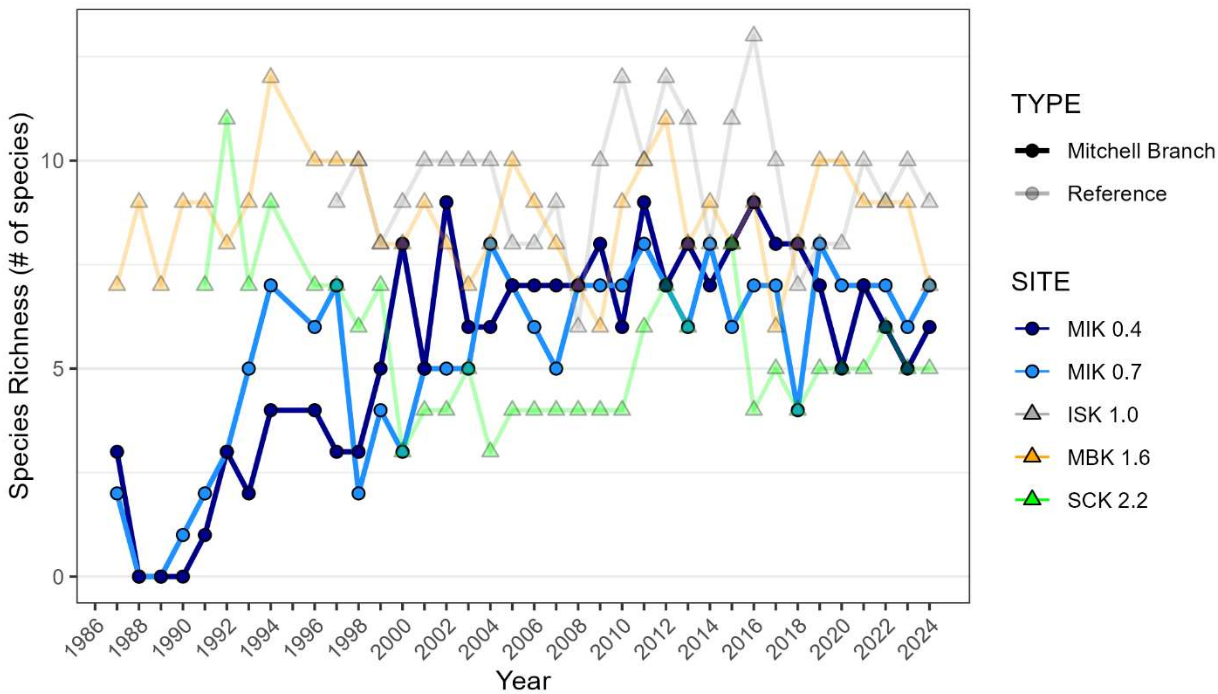


Figure 27. Species richness (number of species) for the fish communities at sites in Mitchell Branch and in reference streams Mill Branch, Scarboro Creek, and Ish Creek, 1987–2024. (ISK = Ish Creek kilometer; MBK = Mill Branch kilometer; SCK = Scarboro Creek kilometer.)

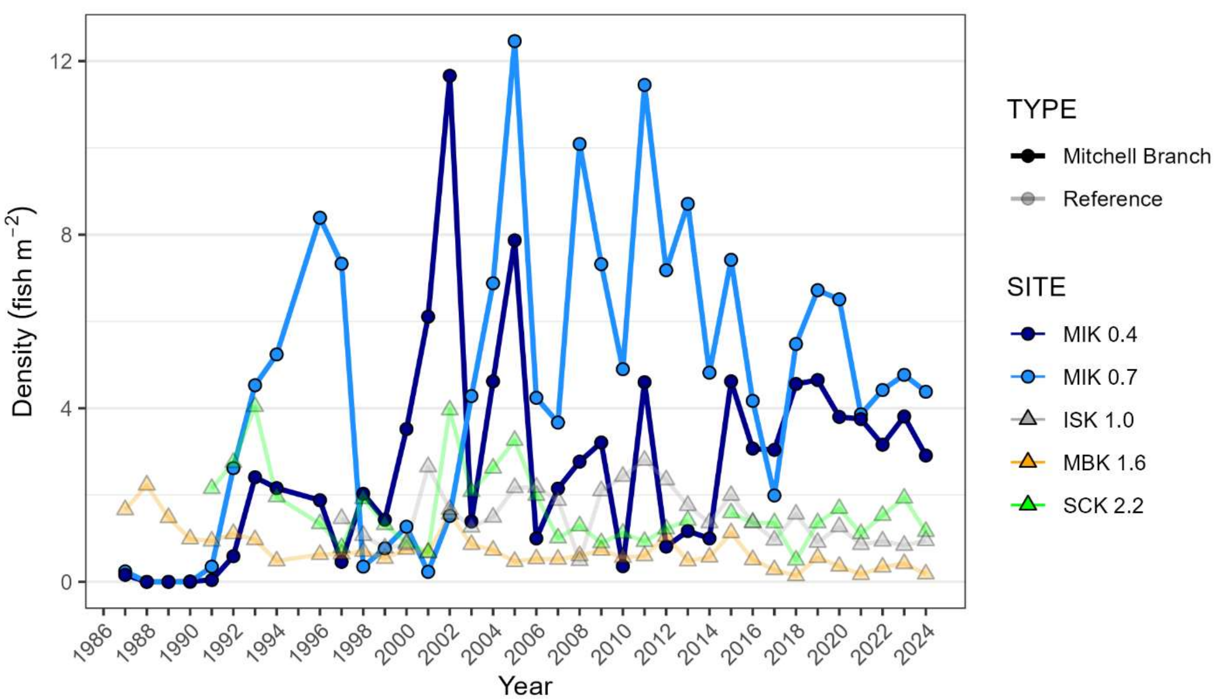


Figure 28. Density (fish/m^2) for the fish communities at sites in Mitchell Branch and in reference streams Mill Branch, Scarboro Creek, and Ish Creek, 1987–2024. (ISK = Ish Creek kilometer; MBK = Mill Branch kilometer; SCK = Scarboro Creek kilometer.)

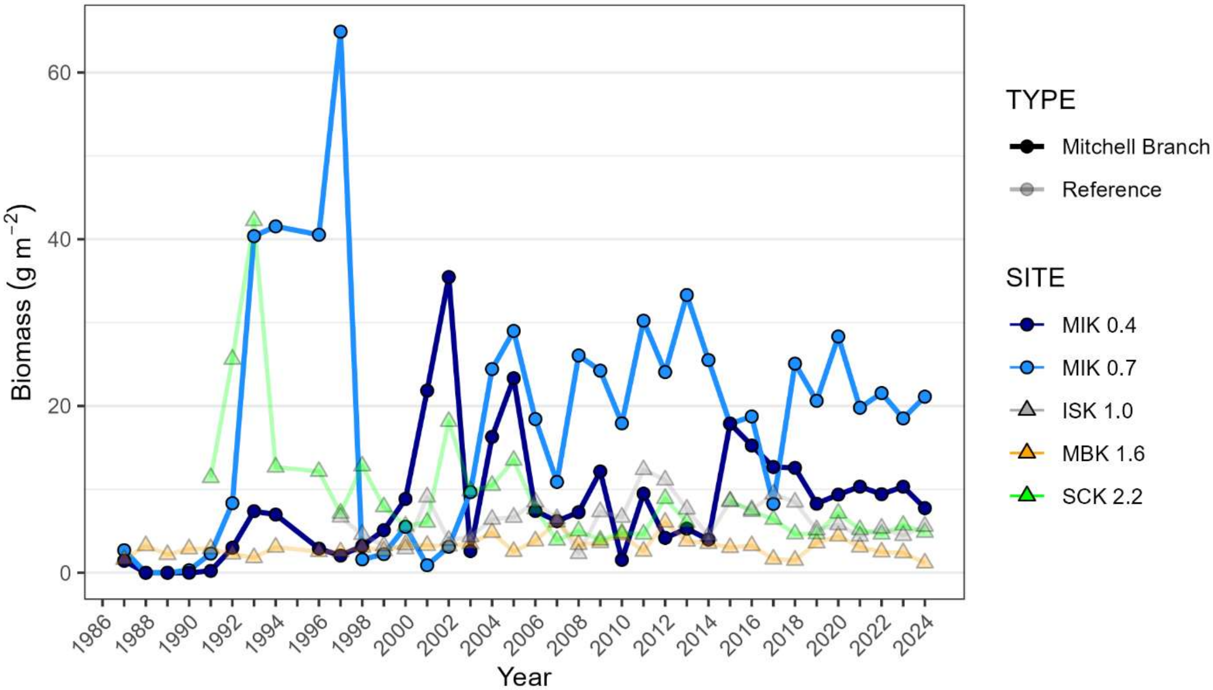


Figure 29. Biomass (g/m^2) for the fish communities at sites in Mitchell Branch and in reference streams Mill Branch, Scarboro Creek, and Ish Creek, 1987–2024. (ISK = Ish Creek kilometer; MBK = Mill Branch kilometer; SCK = Scarboro Creek kilometer.)

At MIKs 0.4 and 0.7, the 2024 sample of community parameters indicated slight fluctuation. Species richness values decreased slightly at both MIKs 0.7 and 0.4 (Figure 27) but remained similar to values observed over the past three years. Density (fish/m^2) at both sites also decreased slightly in 2024 and still remains two to three times higher than that of the reference sites (Figure 28). Biomass decreased slightly at MIK 0.4 and increased at MIK 0.7 in 2024, yet it remained higher than the biomass seen at reference sites—especially at MIK 0.7, where historical habitat impacts have occurred. Only one sensitive species was observed in Mitchell Branch sites in 2024, resulting in low values for both richness and density (Figure 30 and Figure 31). Despite these lower values, there has been a consistency in sensitive species diversity and density at both sampled sites over the past 10 years. This phenomenon can be attributed to the presence of fish such as banded sculpin (*Cottus carolinae*), which have historically been a resident species in Mitchell Branch, and occasional occurrences of other more sensitive fish such as darters and suckers.

In general, the Mitchell Branch fish communities at MIKs 0.4 and 0.7 continue to lack diverse resident species that are sensitive to stress or that have specialized feeding or reproductive requirements, such as darters or suckers that appear at higher frequencies in the reference streams. However, darters and suckers have been occasionally collected in Mitchell Branch sites in recent years. It remains to be seen whether these occurrences will result in resident populations. Similar to the monitoring of benthic communities, fish community monitoring provides an integrated response to the various water chemistry and habitat influences in a stream. Identifying the major stressor influences on the community (i.e., causal analysis) would require additional investigatory strategies coupled with the monitoring data.

During routine bioaccumulation sampling, several species of fish are collected regularly at MIK 0.2 that are rarely observed as part of the Mitchell Branch fish community monitoring activities in the upstream sites. These samplings include several pollution-sensitive species such as snubnose darter (*Etheostoma simoterum*), greenside darter (*Etheostoma blennioides*), black redhorse (*Moxostoma duquesnei*), and northern hogsucker (*Hypentelium nigricans*) (Figure 32). Future monitoring could help determine whether these species have the capacity to establish farther upstream in Mitchell Branch or are merely seasonal migrants to the stream's lower section, which is easily accessible from the much larger Poplar Creek confluence.

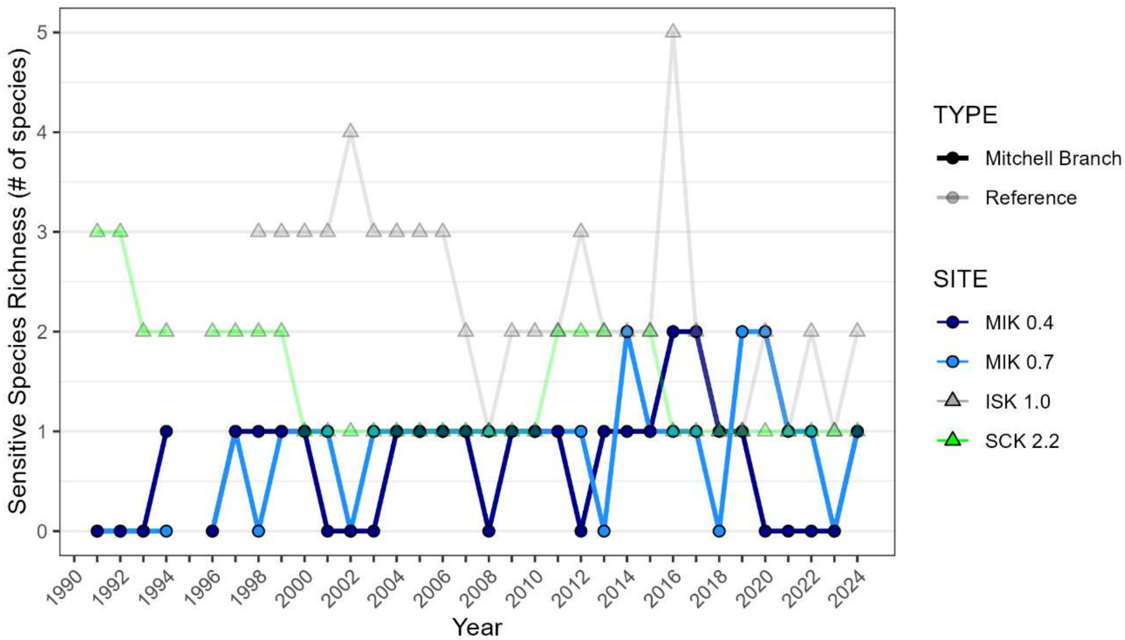


Figure 30. Sensitive species (e.g., banded sculpin and snubnose darter) richness (number of species) of the fish communities at sites in Mitchell Branch and in reference streams Scarboro Creek and Ish Creek, 1991–2024. (ISK = Ish Creek kilometer; SCK = Scarboro Creek kilometer.)

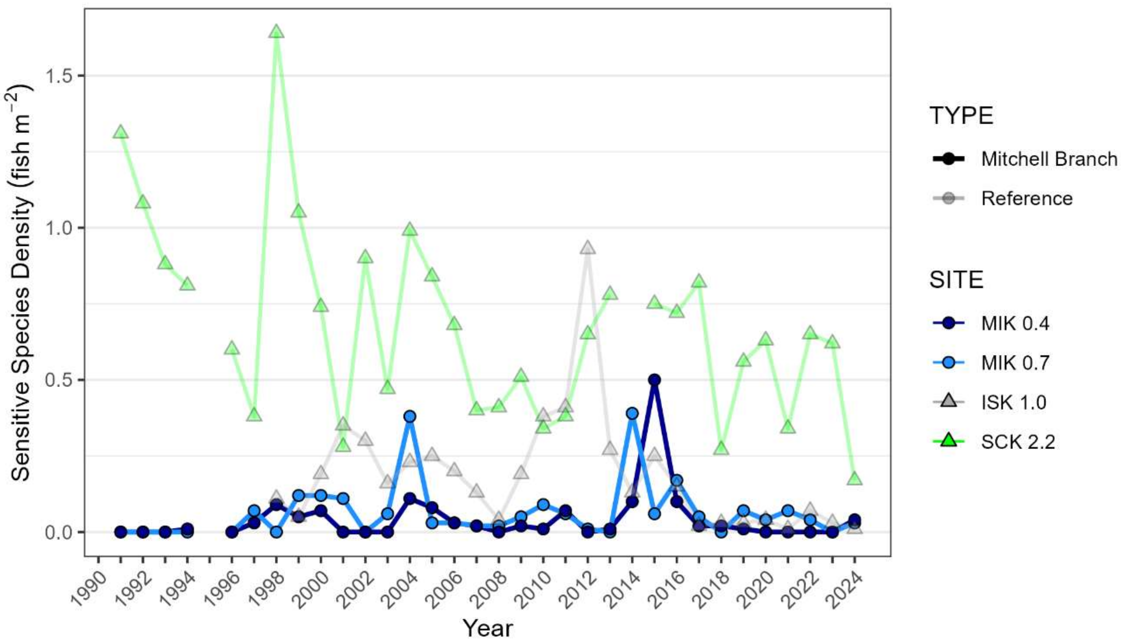
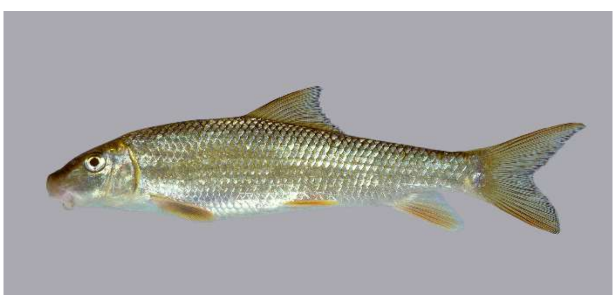


Figure 31. Sensitive species (e.g., banded sculpin and snubnose darter) density (fish/m^2) in the fish communities at sites in Mitchell Branch and in reference streams Scarboro Creek and Ish Creek, 1991–2024. (ISK = Ish Creek kilometer; SCK = Scarboro Creek kilometer.)



Black redhorse (*Moxostoma duquesnei*)

Snubnose darter (*Etheostoma simoterum*)

Northern hogsucker (*Hypentelium nigricans*)

Greenside darter (*Etheostoma blennioides*)

Figure 32. Sensitive fish species observed in lower Mitchell Branch. (Photos: Chris Bryant.)

4.2 K-1007-P1 POND FISH COMMUNITY

The fish communities in the K-1007-P1 Pond are assessed annually. This sampling is conducted to evaluate the effectiveness of remediation efforts implemented in 2009 and aims to reduce the PCBs available for transfer out of the pond via natural routes (i.e., trophic transfer). The remedial actions included capping contaminated sediment with fill dirt, planting native aquatic vegetation to stabilize sediment, and removing potentially contaminated fish from the pond. Initially, fish were removed from the pond using a piscicide (rotenone), and uncontaminated native fish were stocked in the pond with the goal of establishing a sunfish-dominated community. Sunfish have a shorter lifespan than many other species of fish, especially higher–trophic level fish, and their prey source is generally varied but consistently lower on the aquatic food chain compared with species such as largemouth bass; therefore, their presence reduces the likelihood that contaminants will biomagnify within the system.

Despite efforts to remove all unwanted fish from the pond, an unexpected breach in the weir separating the K-1007-P1 Pond from the adjacent Poplar Creek in May 2010 allowed numerous fish to enter the pond during high waters. These unwanted fish constituted several species that were unfavorable to the pond action, including nonnative species and species with life history traits that undermined the remediation efforts, such as a long lifespan and feeding habits that disturb potentially contaminated sediments. Continued work to remove these unwanted fish has been productive, and only limited numbers of the most long-lived species, such as common carp and smallmouth buffalo (*Ictiobus bubalus*), have been encountered in annual monitoring.

Two additional species that returned to the pond after the weir breach were gizzard shad and largemouth bass. Gizzard shad feed on phytoplankton and zooplankton in natural environments such as larger reservoirs; however, in smaller ponds such as the K-1007-P1 Pond, they often turn to feeding on algal growth at the surface of the pond sediment, which can disturb soils and potentially resuspend contaminants in the pond substrate. Largemouth bass tend to be a long-lived species and are a top predator in aquatic environments, making them particularly susceptible to bioaccumulation. They are also a game fish highly prized by many anglers, as well as a common table fare. These two species have also been targeted for removal during continued remediation efforts and fish surveys.

Overall, the K-1007-P1 Pond fish community surveys conducted in February 2024 revealed the presence of 10 species of fish (Figure 33). Over the past several years, the community values have indicated an abundance of sunfish species (bluegill, redear [*Lepomis microlophus*], and warmouth [*Lepomis gulosus*]), which constituted a significant percentage (>93%) of the total fish population in 2024. Bluegill, the most prevalent of these species, were historically the dominant sunfish species in the pond, and they are the desired bioindicator fish species for the remediated pond. Although largemouth bass continue to persist in the pond, their abundance remains relatively low (3%). Despite removal efforts, their presence is expected to continue, given the pond’s current habitat conditions (i.e., abundant prey sources and open water). Gizzard shad continue to be present in the pond and are suspected of reproducing in the past; they constituted an extremely small portion of the fish population in 2021–2024 in contrast to their abundance in 2020. Their abundance fluctuated somewhat each year but, in general, has remained relatively low for the past nine years, with the exception of 2020.

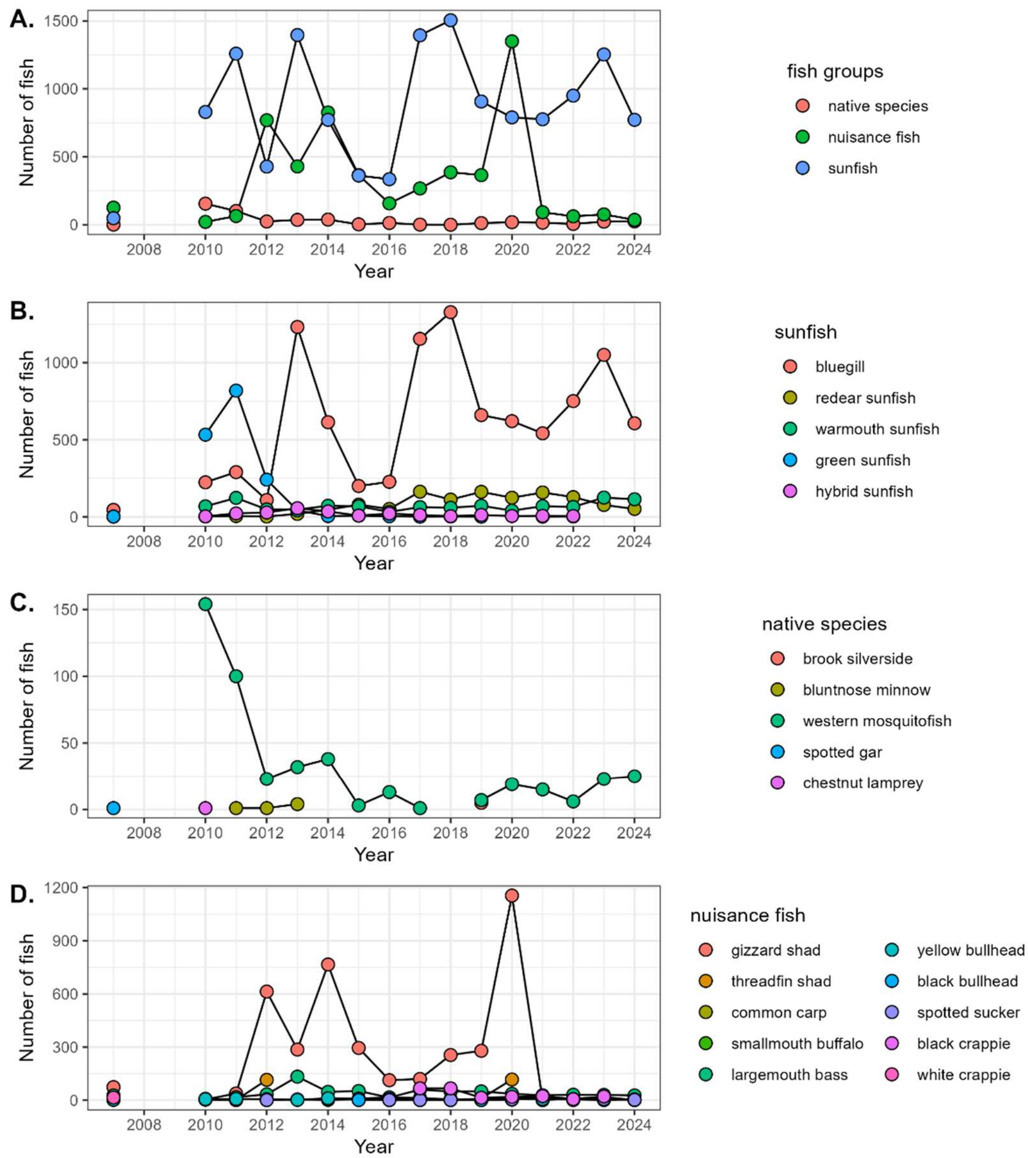


Figure 33. Changes in the K-1007-P1 Pond fish community (% composition) from 2007 to 2024.

In addition to remedial activities at the K-1007-P1 Pond, plant and fish management activities have been conducted at the K-901-A Pond, including the removal of nuisance fish species, planting of aquatic vegetation, and stocking of native sunfish, since 2018. The overall goals are the same: to reduce long-lived and higher–trophic level fish species (as well as any species that may disturb potentially contaminated sediments), establish a native plant community that will help stabilize the pond sediments, and augment the fish community with juvenile sunfish in hopes of creating a sunfish-dominated community.

The fish community was surveyed in February 2024 using a boat electrofisher. The survey revealed the presence of nine species of fish in the pond. Of these, redear sunfish were the most dominant, followed by bluegill. The aquatic plant growth in the pond increased during the growing season in 2024 and filled in most of the open habitat such that there were very limited areas of open water. The recent planting efforts have played a major role in this growth. The planting efforts will continue to create a more sheltered pond habitat that is less suitable for gizzard shad and common carp, with a diverse aquatic plant community. In turn, these efforts will provide more appropriate habitat for sunfish while also stabilizing sediments.

In addition to the planting efforts, nuisance fish were again removed from the K-901-A Pond in 2024 in an effort to shift the fish community to a more sunfish-dominated community (Table 4).

Table 4. Numbers of nuisance fish removed from the K-901-A Pond, 2024.

Species	2024
Common carp (*Cyprinus carpio*)	1
Spotted sucker (*Minytrema melanops*)	2
Yellow bullhead (*Ameiurus natalis*)	1
Largemouth bass (*Micropterus salmoides*)	29
Black crappie (*Pomoxis nigricans*)	1
Total	**34**

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