Final

TAHOE KEYS LAGOONS AQUATIC WEED CONTROL METHODS TEST: BENTHIC MACROINVERTEBRATES

Summary Report

Prepared for
1BTahoe Regional Planning Agency

February 2025

ESA

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Summary Tables

Acronyms and Other Abbreviations

Abbreviation	Definition
AIP	aquatic invasive plant
ANOVA	analysis of variance
APAP	aquatic pesticide application plan
BMI	benthic macroinvertebrate
CMT	Control Methods Test
COC	chain of custody
DF	degrees of freedom
EPT	Ephemeroptera, Plecoptera, Tricoptera
ESA	Environmental Science Associates
IBI	index of biological integrity
LFA	Laminar flow aeration
NPDES	National Pollutant Discharge Elimination System
QAPP	quality assurance project plan
SAFIT	Southwest Association of Freshwater Invertebrate Taxonomists
UV	ultraviolet

INTRODUCTION

The Control Methods Test (CMT) is a three-year project that was implemented in 2022 to assess the effectiveness and utility of tools and methodologies that may improve the management of aquatic invasive plants (AIP) in the Tahoe Keys lagoon system, and in turn, reduce the potential for spread of these plants to Lake Tahoe proper. The overarching goal of the CMT is to determine how well the test methods, or combinations of control approaches, can improve on the "standard" harvesting methods that have been used for over 40 years.

Specific baseline "benchmark" metrics were carefully assessed to describe conditions existing before CMT implementation and during the phases of CMT implementation and to monitor both performance of methods and impacts to the lagoon ecosystems. These measurements included biovolume (mass of plant in the water column); species composition and relative abundance of the aquatic plants, and the condition of invertebrates living in lagoon sediments.

Benthic macroinvertebrates (BMI) were selected as one of the indicators for evaluating ecosystem health within test sites post-treatment. As described in the Revised APAP Amendment 1 (Anderson, 2022):

> *"BMI represent ecosystem health, where the taxonomic identification of a BMI community reflects conditions and changes in water quality, as most BMI species are often extremely sensitive to changes in water quality. Many qualities of BMI exist that make them a good indicator species. Communities of BMI are often species rich and react in varying degrees to changes in their habitats."*

The BMI community within Tahoe Keys was previously sampled in both 2016 and 2019, and results from these surveys indicated that the community was highly tolerant to degraded conditions, typical of lake systems (Anderson, 2022; ESA, 2020). It was anticipated that following the one-time application of herbicides and follow-up use of UV-C light and bottom barriers, the BMI community would initially degrade followed by a return to pre-treatment conditions, or "recovery". It was further anticipated that this recovery may see an improved BMI community indicating improved water quality and a generally less-degraded condition within the lagoons.

This report summarizes the results of BMI sampling conducted as part of the CMT with a focus on evaluating whether the goal of BMI community recovery after three years post-implementation was achieved.

METHODS

Sample Collection and Processing

BMI samples were collected by Environmental Science Associates (ESA) following an adaptation of the California SWAMP (2015) protocol summarized by ESA (2020) such that numbers and locations comply with the Aquatic Pesticide Application Plan (APAP; and APAP amendments), National Pollutant Discharge Elimination System (NPDES) permit, the Monitoring Reporting Program (MRP) and the Quality Assurance Project Plan (QAPP). Two types of samples were collected at each site, shoreline and mid-channel. Shoreline samples were collected within three meters of the shoreline at depths no greater than two meters using a 500-µm mesh D-frame sweep net. Mid-channel samples were collected at depths representative of the center of the site using a petite Ponar grab sampler. After completing the sample collections, the net/Ponar sampler contents were emptied into a clean, labeled bucket of water. Separate buckets were used for shoreline and mid-channel sample areas. Once emptied, the net/Ponar was rinsed over the bucket with a squeeze bottle filled with clean water to ensure the collection of any remaining BMI in the net/Ponar sampler. Subsequent samples collected within each site were added to the corresponding bucket to form a composite sample for each shoreline and mid-channel sample area. Three shoreline and three mid-channel samples were collected at each CMT site.

Each shoreline composite sample was elutriated using a 500-µm mesh sieve. The contents were deposited into one-liter sample bottles, labeled, and covered with 90% denatured alcohol to preserve the samples. Each mid-channel composite sample was elutriated using a 250-µm mesh sieve. Many of the mid-site channel composite samples were too large to fit into a one-liter sample bottle, as a result the composite samples were not bottled in their entirety. To collect a representative mid-channel composite sample, the contents of the bucket were stirred thoroughly prior to elutriation, and the sample was elutriated in small batches until a single one-liter sample bottle was filled. Once filled, the sample bottle was labeled, covered with 90% denatured alcohol, and inverted several times to distribute the alcohol.

Samples were collected primarily during spring of each year (2022-2024) with a limited number of samples collected in fall (**Table 1**). For most sites, samples collected in May 2022 are considered pre-treatment or "before" CMT treatments were implemented. Sites 7, 25, 26, and 27 are unique in that they are all Laminar Flow Aeration (LFA) sites (25, 26, and 27) or an LFA control site (7). LFA in Site 26 was in operation prior to the CMT. The aeration system at Site 25 was initiated during fall 2022 thus subsequent BMI monitoring in LFA sites was conducted in the fall.

Water levels in the West Lagoon varied greatly between the three sampling years, with relatively low levels in Year 1, approximately three feet higher in Year 2 and five feet higher in Year 3 (compared to Year 1). This resulted in shoreline areas being inundated in Years 2 and 3 that were not otherwise inundated in Year 1. However, this was not considered to be problematic as invertebrates recolonize areas quickly throughout the year as water levels rise and fall.

TABLE 1
TAHOE KEYS CMT BMI SAMPLE COLLECTION DATES

Site	2022	2023	2024
1	5/3/2022	5/8/2023	5/9/2024
2	5/3/2022	5/8/2023	5/9/2024
3	5/3/2022	5/8/2023	5/9/2024
5	5/3/2022	5/8/2023	5/9/2024
7	10/31/2022	5/8/2023, 10/25/2023	10/22/2024
8	5/3/2022	5/8/2023	5/9/2024
9	5/3/2022	5/8/2023	5/9/2024
10	5/3/2022	5/8/2023	5/9/2024
11	5/3/2022	5/8/2023	5/9/2024
12	5/3/2022	5/8/2023	5/9/2024
13	5/3/2022	5/8/2023	5/9/2024
14	5/3/2022	5/8/2023	5/9/2024
15	5/3/2022	5/8/2023	5/9/2024
16	5/3/2022	5/8/2023	5/9/2024
17	5/3/2022	5/8/2023	5/9/2024
18	5/3/2022	5/8/2023	5/9/2024
19	5/3/2022	5/8/2023	5/9/2024
20	5/3/2022	5/8/2023	5/9/2024
22	5/3/2022	5/8/2023	5/9/2024
23	5/3/2022	5/8/2023	5/9/2024
24	5/3/2022	5/8/2023	5/9/2024
25	5/3/2022, 10/31/2022	5/8/2023, 10/25/2023	10/22/2024
26	5/3/2022	5/8/2023	10/22/2024
27	5/3/2022, 10/31/2022	5/8/2023, 10/25/2023	5/9/2024, 10/22/2024

Following collection and preservation, chain of custody (COC) forms were completed and accompanied the samples during their transfer to Marine Taxonomic Services (MTS) in San Diego, CA for sorting. After inspecting the samples for proper preservation and storage, a quality control check was performed to ensure a sorting efficacy of 95%. Samples were then sent by mail or MTS staff to Aquatic Biology Associates, Inc. in Corvallis, OR for taxonomic identification. Identification protocols included a Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) Level 2 taxonomic effort, Chironomidae (midges) were identified to genus/species group, Oligochaeta (segmented worms) to class Oligochaeta, and Acari (mites) to subclass Acari.

Analysis

All statistical analyses and preparation of graphics were carried out in R (R Core Team, 2024).

Individual Metrics

Common metrics of BMI community health were calculated from processed samples. These metrics included overall richness, a count of all unique taxa; Ephemeroptera, Plecoptera, Tricoptera (EPT) richness, a count of unique sensitive taxa; relative abundance of the most dominant taxa, a measure of diversity; average tolerance of all sampled individuals; and functional feeding group composition (a measure of trophic diversity).

Adapted Index of Biological Integrity

The index of biological integrity (IBI) for Eastern Sierra Streams and Rivers uses 10 metrics to produce an overall score for a given stream based on the BMI community present within riffle habitats (Herbst and Silldorff, 2009). These metrics include five measures of richness, three compositional measures, three tolerance measures, and one functional measure. The final preferred IBI contains 10 metric indices which are summed together to derive a final IBI score. The indices for the IBI were developed by calculating the raw values for each metric for a number of reference sites which were deemed “unimpacted”. The median of these raw values was used as the highest possible index score (10) while the lower 10^{th} percentile value was used as the lowest possible index (0). Raw values between the lower 10^{th} percentile and median values are scaled to these indices. For further information, refer to Herbst and Silldorff (2009). Currently, no such index exists for lakes and other lentic waterbodies.

To assess changes in the BMI community within this study, a similar approach was followed, using the pre-treatment samples to develop the thresholds for the 10-metric IBI. If raw values for both the median and lower 10^{th} percentile of a metric was 0 in the pre-treatment condition, that metric was dropped. This resulted in a 6-metric IBI for the study area. Each metric and index score are presented below in **Table 2**. Following the methods for the original IBI, the indices for the modified IBI were developed by calculating the raw values for each metric for all sites during the “Pre-Treatment” condition. The 90^{th} percentile of these raw values was used as the highest possible index score (10) while the lower 10^{th} percentile value was used as the lowest possible index (0). Raw values between the 10^{th} percentile and 90^{th} percentile values are scaled to these indices. For example, for the metric Total Taxa Richness the lower 10^{th} percentile was 3 species while the 90^{th} percentile value was 23 species. Therefore, 3 species or less would be scored 0, 23 species or more would be scored 10, and a 6 species would be scored on the 0-10 scale according to the equation below.

$$10 * \frac{6\text{ (species)} - 3\text{ (the }10^{th}\text{ percentile)}}{23\text{(the }90^{th}\text{ percentile)} - 3\text{ (the }10^{th}\text{ percentile)}} = 10 * \frac{3}{20} = 10 * 0.15 = 1.5$$

Table 2 shows the bookend values for each metric and the scaling calculation which scales the raw value on a 0 – 10 scale.

TABLE 2
TAHOE KEYS CMT IBI – SCALED CALCULATIONS

Metric	Score & Scaled-Metric Calculation	Metric Value Range
Richness		
Total Taxa Richness	0	If ≤ 3
	10	If ≥ 14
	10*(*Richness* – 3) / (14 – 3)	If between 3 - 14
Composition		
Chironomidae (midge) Abundance (relative to total sample)	0	If ≥ 67%
	10	If ≤ 29%
	10*(67 - *Midge Relative Abundance*) / (67 – 29)	If between 29% - 67%
Abundance of top 3 most dominant taxa (relative to total sample)	0	If 100%
	10	If ≤ 47%
	10*(100 – *Dominant Taxa Relative Abundance*) / (100 – 47)	If between 47 – 100%
Tolerance		
Abundance of most tolerant taxa (TV = 7 -10) (relative to total sample)	0	If ≥ 65%
	10	If ≤ 33%
	10*(65 – *Tolerant Taxa Relative Abundance*) / (65 – 33)	If between 33 – 65%
Average tolerance value of individuals in the sample	0	If ≥ 8.1
	10	If ≤ 6.0
	10*(8.1 – *Average Tolerance*) / (8.1 – 6.0)	If between 6.0 – 8.1
Function		
Predator Taxa Richness	0	If ≤ 1
	10	If ≥ 9
	10*(*Predator Richness* – 1) / (9 – 1)	If between 1 - 9

Statistical Analysis

Analysis of Variance (ANOVA) was used to determine if significant differences were found among samples for each of the individual metrics above. For each metric the ANOVA tests means of various groupings of the data (for example: waterbody [West Lagoon, Lake Tallac], site [i.e., treatment type], treatment period [i.e., before or after], habitat type, and the interaction of these) to determine if there are any statistically meaningful differences among them. Significant differences in the ANOVA for a specific grouping would indicate that the means of the groups (for example, waterbodies: West Lagoon vs. Lake Tallac or habitat: Near-shore vs. Mid-Channel) are significantly different and there is likely an effect of this group on the metric.

Boxplots were used to compare all samples collected pre-treatment with all samples collected post-treatment, specifically addressing the question of recovery within each metric and the IBI. This comparison included a statistical test (Wilcoxon test) of the difference between the before treatment and after treatment value of the metric. The Wilcoxon test was used because the samples are not independent (the pre-treatment and post-treatment samples are considered repeated measures, as are the samples within a site) and normality of the distribution could not be assured, which does not allow the use of the more common *t*-test or paired *t*-test. However, the Wilcoxon test still provides a *p*-value which assigns a statistical significance to the differences between group means. It should be noted that application of this comparison when no statistical difference is found using the ANOVA assumes the risk of elevated Type-I error and thus significant differences seen in these figures should be considered following Bonferroni correction with a lower α of 0.001.

RESULTS

Richness

Overall

Richness across all species showed minimal change post-treatment compared to pre-treatment. Although overall richness was found to be significantly different between treatment sites and habitats (mid-channel and near-shore), no significant differences were found between period or the interactions of period, treatment site, and habitat (**Table 3**). In both Lake Tallac and the West Lagoon, richness generally decreased in 2023 in both treatment and control sites, then increased during Spring 2024 (**Figure 1**). Near-shore habitats had consistently higher richness than mid-channel habitats in both the West Lagoon and Lake Tallac and all treatments. No changes in richness between years were found to be statistically significant.

TABLE 3
SUMMARY ANOVA TABLE FOR OVERALL RICHNESS

Source	Df	Sum Sq	Mean Sq	F-value	P-Value
Waterbody	1	72.029	72.029	2.840	0.095
Period	1	1.017	1.017	0.040	0.842
Site	8	762.612	95.326	3.758	0.001 ***
Habitat	1	11,156.926	11,156.926	439.870	0.000 ***
Waterbody:Period	1	57.917	57.917	2.283	0.134
Waterbody:Site	2	31.193	15.597	0.615	0.543
Period:Site	8	95.647	11.956	0.471	0.874
Waterbody:Habitat	1	7.449	7.449	0.294	0.589
Period:Habitat	1	0.261	0.261	0.010	0.919
Site:Habitat	8	137.332	17.167	0.677	0.711
Waterbody:Period:Site	2	40.525	20.262	0.799	0.453
Waterbody:Period:Habitat	1	1.341	1.341	0.053	0.819
Waterbody:Site:Habitat	2	2.575	1.287	0.051	0.951
Period:Site:Habitat	8	142.810	17.851	0.704	0.688
Waterbody:Period:Site:Habitat	2	0.998	0.499	0.020	0.981
Residuals	100	2,536.417	25.364		

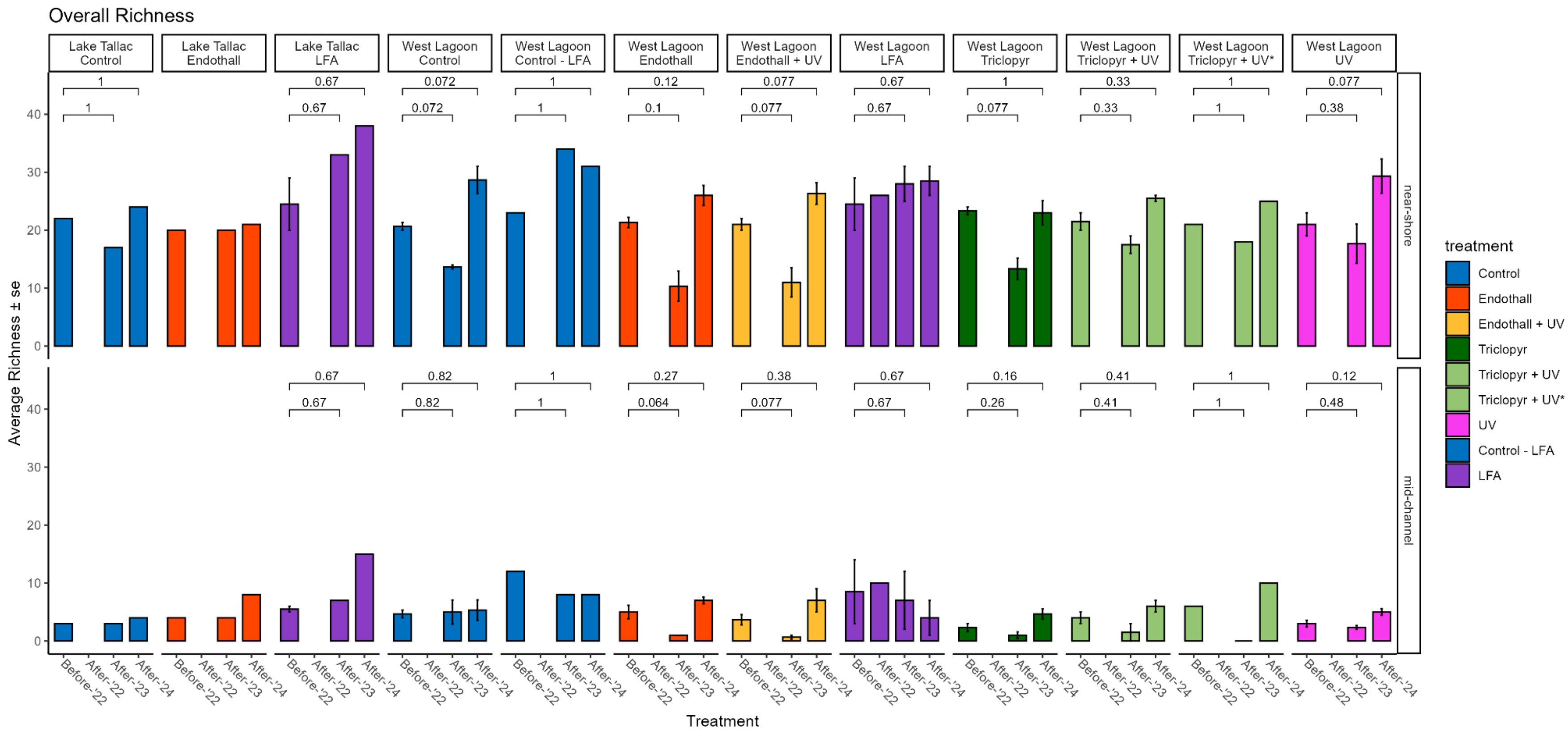

Figure 1

Overall species richness for each year, for each treatment group within each area, for each habitat type (mid-channel and near-shore). Bars without statistical comparisons above consist of single samples and are therefore not statistically compared. Numbers with brackets indicate the *p*-value of Wilcoxon tests between the Pre-Treatment year and each Post-Treatment year for years with more than one sample, where *p*< 0.001 is significant. Triclopyr + UV* = Site 12 which did not receive the intended UV treatments.

EPT-Taxa

EPT-taxa were rare within all sites in the study area, especially in mid-channel habitats, where they were generally absent, contrasted with preferred shallow habitats of these species (**Figure 2**). Similar to overall richness, differences in richness among site and habitats were significant, as was the interaction between waterbody and period (**Table 4**). Additionally, the interactions between waterbody and habitat, site and habitat, and waterbody-period-habitat were also significant. This was likely due to the observance of additional species in 2024 compared to 2022 in all Lake Tallac sites which may indicate increasing EPT Richness in this waterbody.

TABLE 4
SUMMARY ANOVA TABLE FOR EPT-TAXA RICHNESS

Source	Df	Sum Sq	Mean Sq	F-value	P-Value
Waterbody	1	4.270	4.270	6.987	0.010
Period	1	0.453	0.453	0.742	0.391
Site	8	15.361	1.920	3.142	0.003 ***
Habitat	1	78.811	78.811	128.951	0.000 ***
Waterbody:Period	1	5.551	5.551	9.082	0.003 ***
Waterbody:Site	2	0.411	0.205	0.336	0.715
Period:Site	8	2.167	0.271	0.443	0.892
Waterbody:Habitat	1	3.170	3.170	5.188	0.025 *
Period:Habitat	1	0.119	0.119	0.195	0.660
Site:Habitat	8	14.729	1.841	3.012	0.005 **
Waterbody:Period:Site	2	0.419	0.209	0.342	0.711
Waterbody:Period:Habitat	1	3.449	3.449	5.644	0.019 *
Waterbody:Site:Habitat	2	0.979	0.490	0.801	0.452
Period:Site:Habitat	8	2.247	0.281	0.460	0.882
Waterbody:Period:Site:Habitat	2	0.938	0.469	0.767	0.467
Residuals	100	61.117	0.611		

Notes:
Significance level: * ($p \leq 0.05$), ** ($p \leq 0.01$), ***($p < 0.001$)
DF = Degrees of Freedom
SUM SQ = Sum of Squares
MEAN SQ = Mean Square

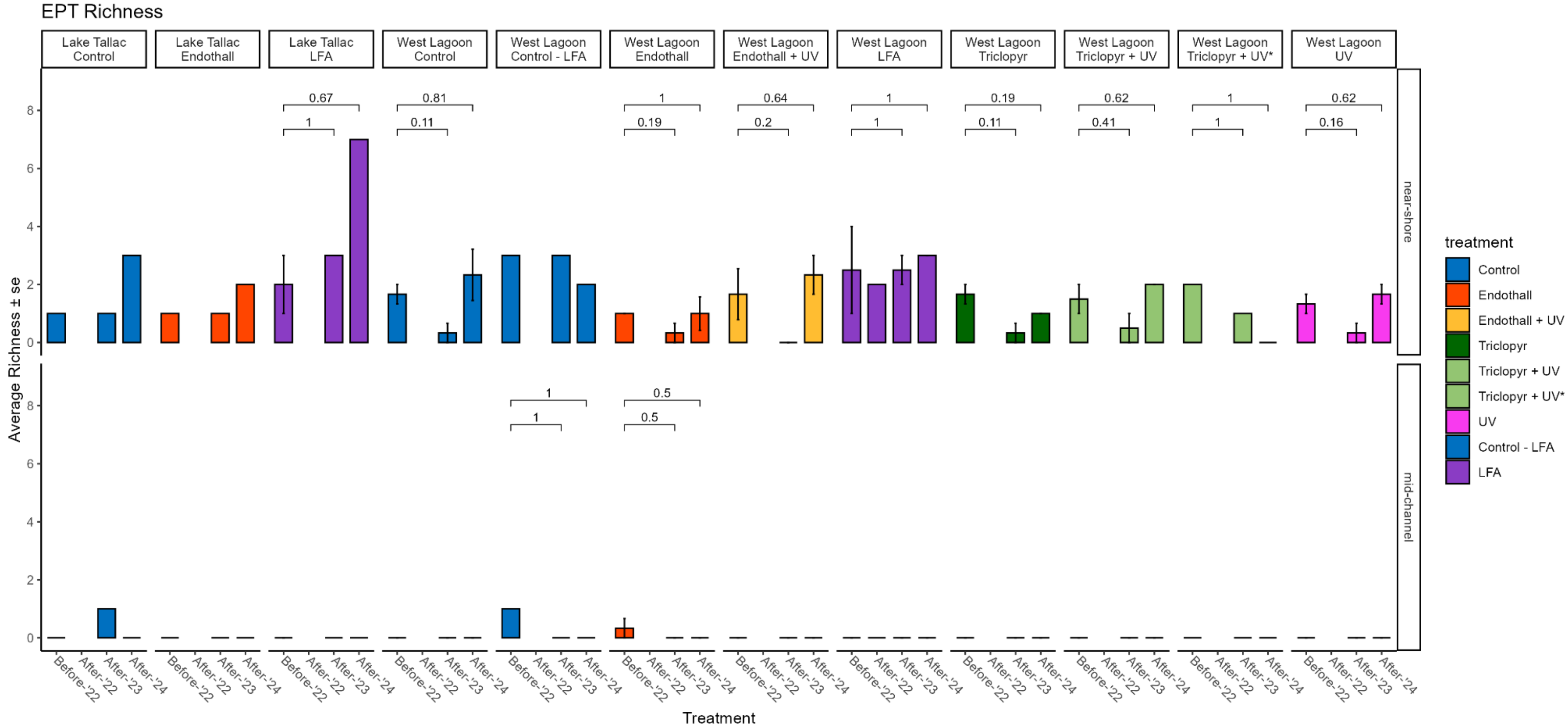

Figure 2

EPT-taxa species richness for each year, for each treatment group within each area, for each habitat type (mid-channel and near-shore). Bars without statistical comparisons above consist of single samples and are therefore not statistically compared. Numbers with brackets indicate the *p*-value of Wilcoxon tests between the Pre-Treatment year and each Post-Treatment year for years with more than one sample, where *p*< 0.001 is significant. Triclopyr + UV* = Site 12 which did not receive the intended UV treatments.

Diversity

The most dominant taxa collected during pre-treatment sampling ranged from 12% to 61% of the total abundance, averaging to 28%. In Lake Tallac, the dominant taxa abundances comprised 16-57% of the total abundance pre-treatment and 18-73% of the total abundance post-treatment with no statistical difference between pre- and post-treatment for any treatment (**Tables 5** and **6**). However, the LFA treatment site in Lake Tallac was lower in both pre- and post-treatment samples than the Lake Tallac Control site. While dominant taxa relative abundance was significant between habitat types, no other terms were found to be significant.

TABLE 5
PERCENT OF TOTAL ABUNDANCE COMPRISED BY DOMINANT TAXA

Treatment	Before Treatment *Mean (Min – Max)*	After Treatment *Mean (Min – Max)*
Lake Tallac		
Control	37% (24% - 50%)	46% (33% - 65%)
Endothall	37% (18% - 57%)	40% (25% - 73%)
LFA	28% (16% - 39%)	19% (16% - 28%)
West Lagoon		
Control	37% (25% - 50%)	43% (13% - 100%)
Control - LFA	39% (36% - 43%)	24% (20% - 33%)
Endothall	35% (24% - 64%)	52% (14% - 100%)
Endothall + UV	44% (21% - 78%)	51% (21% - 100%)
LFA	35% (17% - 50%)	45% (19% - 100%)
Triclopyr	36% (17% - 50%)	45% (24% - 100%)
Triclopyr + UV	48% (35% - 78%)	34% (20% - 57%)
Triclopyr + UV–Site 12	61% (43% - 78%)	41% (25% - 58%)
UV	45% (24% - 75%)	42% (19% - 80%)

Notes:
Significance level: * ($p \leq 0.05$), ** ($p \leq 0.01$), ***($p < 0.001$)
DF = Degrees of Freedom
SUM SQ = Sum of Squares
MEAN SQ = Mean Square

TABLE 6
SUMMARY ANOVA TABLE FOR DOMINANT TAXA ABUNDANCE

Source	Df	Sum Sq	Mean Sq	F-value	P-Value
Waterbody	1	0.132	0.132	3.619	0.060
Period	1	0.030	0.030	0.813	0.370
Site	8	0.282	0.035	0.965	0.468
Habitat	1	1.797	1.797	49.145	0.000 ***
Waterbody:Period	1	0.003	0.003	0.070	0.792
Waterbody:Site	2	0.098	0.049	1.346	0.265

Source	Df	Sum Sq	Mean Sq	F-value	P-Value
Period:Site	8	0.291	0.036	0.996	0.445
Waterbody:Habitat	1	0.009	0.009	0.245	0.622
Period:Habitat	1	0.008	0.008	0.224	0.637
Site:Habitat	8	0.250	0.031	0.853	0.559
Waterbody:Period:Site	2	0.029	0.014	0.392	0.677
Waterbody:Period:Habitat	1	0.044	0.044	1.213	0.274
Waterbody:Site:Habitat	2	0.003	0.002	0.045	0.956
Period:Site:Habitat	8	0.128	0.016	0.437	0.896
Waterbody:Period:Site:Habitat	2	0.030	0.015	0.409	0.665
Residuals	94	3.438	0.037		

Notes:
Significance level: * ($p \leq 0.05$), ** ($p \leq 0.01$), ***($p < 0.001$)
DF = Degrees of Freedom
SUM SQ = Sum of Squares
MEAN SQ = Mean Square

Dominant taxa consisted of Nematocera (midges) in 26 samples, Oligochaeta (worms) in 15 samples, Ostracoda (seed shrimp) in 11 samples, Nemata (roundworms) in 6 samples, Cladocera (waterfleas) in 5 samples, Amphipoda (amphipods) in 4 samples, and Ephemeroptera (mayflies) in 2 samples.

Tolerance

Tolerance varied between period, site, and habitat; however, only the differences among sites were found to be statistically significant (**Table 7**). Despite non-significance, many sites showed a discernible decrease in average tolerance in post-treatment samples, indicating a shift toward potentially less degraded conditions (**Figure 3**). The significant difference among sites likely comes from the high range in average tolerance values for sites irrespective of period or habitat type, Site 14 had the lowest tolerance (mean = 5.16) while Site 18 had the highest tolerance (mean = 8.03). Average tolerance does show some difference between waterbody, with Lake Tallac showing a slightly higher tolerance value (mean = 7.25) compared to the West Lagoon (mean = 6.87). This difference is expected given the lack of connectivity Lake Tallac has to Lake Tahoe and increased organic detritus from the surrounding forested shorelines compared with the West Lagoon which would lead to differences in water quality. There was a slight difference between pre- and post-treatment for all sites. Sites before treatment had an average tolerance value of 7.12 while sites after treatment had a tolerance value of 6.82, which may indicate a shift toward potentially less degraded conditions post treatment, overall. However, on a site by site basis, there is effectively no difference between pre- and post-treatment (Period:Site $p = 0.922$).

TABLE 7
SUMMARY ANOVA TABLE FOR TOLERANCE

Source	Df	Sum Sq	Mean Sq	F-value	P-Value
Waterbody	1	2.543	2.543	1.009	0.318
Period	1	2.727	2.727	1.082	0.301
Site	8	44.458	5.557	2.205	0.033 *
Habitat	1	0.057	0.057	0.023	0.881
Waterbody:Period	1	0.005	0.005	0.002	0.965
Waterbody:Site	2	1.070	0.535	0.212	0.809
Period:Site	8	7.909	0.989	0.392	0.922
Waterbody:Habitat	1	1.044	1.044	0.414	0.521
Period:Habitat	1	0.625	0.625	0.248	0.620
Site:Habitat	8	28.803	3.600	1.429	0.194
Waterbody:Period:Site	2	0.375	0.187	0.074	0.928
Waterbody:Period:Habitat	1	0.794	0.794	0.315	0.576
Waterbody:Site:Habitat	2	0.831	0.415	0.165	0.848
Period:Site:Habitat	8	4.256	0.532	0.211	0.988
Waterbody:Period:Site:Habitat	2	0.051	0.026	0.010	0.990
Residuals	98	246.952	2.520		

Notes:
Significance level: * ($p \leq 0.05$), ** ($p \leq 0.01$), ***($p < 0.001$)
DF = Degrees of Freedom
SUM SQ = Sum of Squares
MEAN SQ = Mean Square

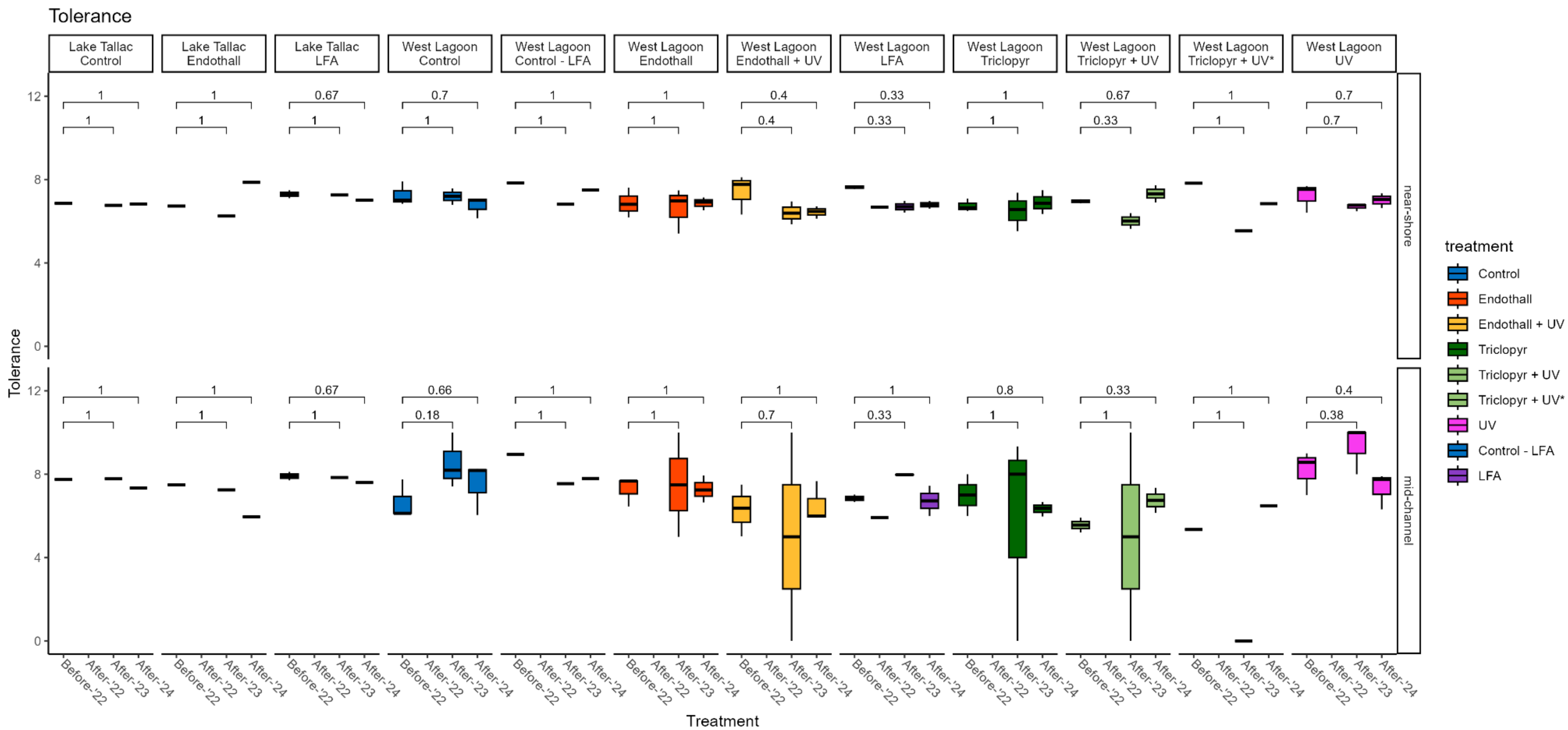

Figure 3

Average BMI tolerance values for each year, for each treatment group within each area, for each habitat type (mid-channel and near-shore). Bars without statistical comparisons above consist of single samples and are therefore not statistically compared. Numbers with brackets indicate the *p*-value of Wilcoxon tests between the Pre-Treatment year and each Post-Treatment year for years with more than one sample, where *p*< 0.001 is significant. Triclopyr + UV* = Site 12 which did not receive the intended UV treatments.

Trophic Diversity

Trophic diversity, represented by the relative abundance of various functional feeding groups, showed trends which were unique to each feeding group (**Figure 4**), discussed in greater detail below.

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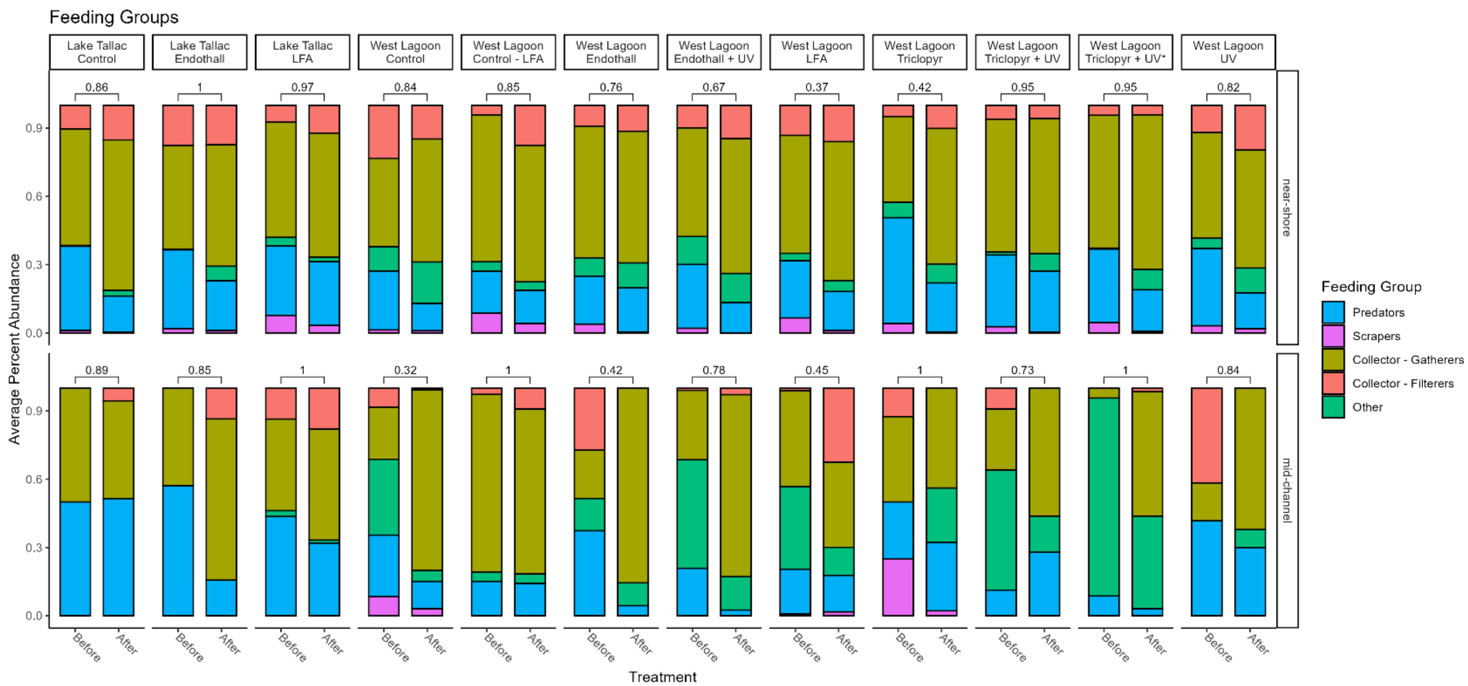

Figure 4
Functional Feeding group composition pre- and post-treatment, for each treatment group within each area, for each habitat type (mid-channel and near-shore). Bars without statistical comparisons above consist of single samples and are therefore not statistically compared. Numbers with brackets indicate the *p*-value of Wilcoxon tests between the Pre-Treatment year and each Post-Treatment year for years with more than one sample, where *p*< 0.001 is significant. Triclopyr + UV* = Site 12 which did not receive the intended UV treatments.

Gatherers

Gatherers were the most common macroinvertebrate, representing 54% of total macroinvertebrate abundance on average. Gatherers also showed the most significant difference pre- and post-treatment, with abundances almost doubling from an average of 40% pre-treatment to an average of 60% post-treatment (**Table 8**). When compared across habitat type and period, average mid-channel gatherer abundances increased (pre-treatment: 31%, post-treatment: 63%) more than near-shore gatherer abundances (pre-treatment: 49%, post-treatment: 58%).

TABLE 8
SUMMARY ANOVA TABLE FOR THE RELATIVE ABUNDANCE OF GATHERERS

Source	Df	Sum Sq	Mean Sq	F-value	P-Value
Gatherers					
Waterbody	1	0.004	0.004	0.077	0.782
Period	1	1.309	1.309	28.451	0.000 ***
Site	8	0.388	0.048	1.053	0.403
Habitat	1	0.032	0.032	0.692	0.408
Waterbody:Period	1	0.079	0.079	1.714	0.194
Waterbody:Site	2	0.009	0.005	0.102	0.903
Period:Site	8	0.327	0.041	0.888	0.530
Waterbody:Habitat	1	0.002	0.002	0.047	0.829
Period:Habitat	1	0.446	0.446	9.687	0.002 ***
Site:Habitat	8	0.383	0.048	1.040	0.412
Waterbody:Period:Site	2	0.069	0.035	0.752	0.474
Waterbody:Period:Habitat	1	0.084	0.084	1.832	0.179
Waterbody:Site:Habitat	2	0.106	0.053	1.155	0.320
Period:Site:Habitat	8	0.416	0.052	1.130	0.351
Waterbody:Period:Site:Habitat	2	0.102	0.051	1.105	0.335
Residuals	94	4.326	0.046		

Notes:
Significance level: * ($p \leq 0.05$), ** ($p \leq 0.01$), ***($p < 0.001$)
DF = Degrees of Freedom
SUM SQ = Sum of Squares
MEAN SQ = Mean Square

Predators

Predators, on average, represented 22% of BMI and showed significant differences between waterbodies and period, occurring more frequently in Lake Tallac (33%) compared to the West Lagoon (21%), and occurring more frequently before treatment (30%) compared to post-treatment (18%) (**Table 9**, **Figure 4**). However, the interaction between these terms did not show a significant difference, nor did any other term.

TABLE 9
SUMMARY ANOVA TABLE FOR THE RELATIVE ABUNDANCE OF PREDATORS

Source	Df	Sum Sq	Mean Sq	F-value	P-Value
Predators					
Waterbody	1	0.250	0.250	7.006	0.010 **
Period	1	0.408	0.408	11.415	0.001 ***
Site	8	0.392	0.049	1.370	0.220
Habitat	1	0.000	0.000	0.005	0.946
Waterbody:Period	1	0.002	0.002	0.055	0.816
Waterbody:Site	2	0.027	0.013	0.375	0.689
Period:Site	8	0.150	0.019	0.525	0.835
Waterbody:Habitat	1	0.092	0.092	2.566	0.113
Period:Habitat	1	0.003	0.003	0.076	0.783
Site:Habitat	8	0.181	0.023	0.633	0.748
Waterbody:Period:Site	2	0.011	0.006	0.157	0.855
Waterbody:Period:Habitat	1	0.006	0.006	0.154	0.696
Waterbody:Site:Habitat	2	0.028	0.014	0.393	0.676
Period:Site:Habitat	8	0.230	0.029	0.806	0.599
Waterbody:Period:Site:Habitat	2	0.019	0.009	0.264	0.769
Residuals	94	3.359	0.036		

Notes:
Significance level: * ($p \leq 0.05$), ** ($p \leq 0.01$), ***($p < 0.001$)
DF = Degrees of Freedom
SUM SQ = Sum of Squares
MEAN SQ = Mean Square

Filterers

Filterers represented 11% of sampled macroinvertebrates and showed the most variation between samples. Filterers comprised an average of 8% of mid-channel abundances and an average of 13% of near-shore abundances, an almost significant difference (**Table 10**). Additionally, significant differences were further seen between habitat types pre- and post-treatment; mid-channel filterer abundances dropped from 13% to 6% between pre- and post-treatment, while near-shore abundances increased, from 11% pre-treatment to 13% post-treatment (**Figure 4**). There was also an almost significant interaction effect of site and period on filterer abundances. In the UV treatment sites, filterer abundances decreased from 27% pre-treatment to 9% post-treatment, the largest change in abundance (66% change), while other sites, including the control, saw more modest changes of 20-30%. The interaction between the three terms (period, site, habitat) was also almost significant indicating that changes in filterer abundance were different across these combinations.

TABLE 10
SUMMARY ANOVA TABLE FOR THE RELATIVE ABUNDANCE OF FILTERERS

Source	Df	Sum Sq	Mean Sq	F-value	P-Value
Filterers					
Waterbody	1	0.003	0.003	0.140	0.709
Period	1	0.009	0.009	0.516	0.474
Site	8	0.247	0.031	1.717	0.104
Habitat	1	0.065	0.065	3.613	0.060
Waterbody:Period	1	0.035	0.035	1.954	0.165
Waterbody:Site	2	0.018	0.009	0.502	0.607
Period:Site	8	0.216	0.027	1.504	0.166
Waterbody:Habitat	1	0.001	0.001	0.048	0.826
Period:Habitat	1	0.075	0.075	4.189	0.043 *
Site:Habitat	8	0.144	0.018	1.003	0.439
Waterbody:Period:Site	2	0.061	0.031	1.712	0.186
Waterbody:Period:Habitat	1	0.027	0.027	1.481	0.227
Waterbody:Site:Habitat	2	0.008	0.004	0.212	0.809
Period:Site:Habitat	8	0.256	0.032	1.782	0.090
Waterbody:Period:Site:Habitat	2	0.071	0.035	1.972	0.145
Residuals	94	1.688	0.018		

Notes:
Significance level: * ($p \leq 0.05$), ** ($p \leq 0.01$), ***($p < 0.001$)
DF = Degrees of Freedom
SUM SQ = Sum of Squares
MEAN SQ = Mean Square

Other Consumers

Other consumers (for example, parasitic consumers) comprised another 12% on average across all samples. Abundances of other consumers were higher in samples from the West Lagoon (mean: 13%), compared to Lake Tallac (mean: 2%) (Figure 4). Additionally, other consumers were more common in mid-channel samples (mean: 15%) compared to near-shore samples (mean: 8%). There was also a significant difference among habitat types when compared across period; mid-channel samples decreased between pre-treatment (mean: 23%) and post-treatment (mean: 10%), while near-shore samples increased between pre-treatment (mean: 6%) and post-treatment (mean: 10%) (**Table 11**).

TABLE 11
SUMMARY ANOVA TABLE FOR THE RELATIVE ABUNDANCE OF PREDATORS

Source	Df	Sum Sq	Mean Sq	F-value	P-Value
Other Consumers					
Waterbody	1	0.222	0.222	9.585	0.003 ***
Period	1	0.070	0.070	3.015	0.086
Site	8	0.335	0.042	1.810	0.085
Habitat	1	0.189	0.189	8.165	0.005 **
Waterbody:Period	1	0.012	0.012	0.504	0.479
Waterbody:Site	2	0.008	0.004	0.170	0.844
Period:Site	8	0.293	0.037	1.581	0.141
Waterbody:Habitat	1	0.050	0.050	2.154	0.146
Period:Habitat	1	0.196	0.196	8.468	0.005 **
Site:Habitat	8	0.449	0.056	2.425	0.020 *
Waterbody:Period:Site	2	0.003	0.002	0.072	0.930
Waterbody:Period:Habitat	1	0.028	0.028	1.209	0.274
Waterbody:Site:Habitat	2	0.017	0.008	0.367	0.694
Period:Site:Habitat	8	0.321	0.040	1.732	0.101
Waterbody:Period:Site:Habitat	2	0.015	0.007	0.321	0.726
Residuals	94	2.175	0.023		

Notes:
Significance level: * ($p \leq 0.05$), ** ($p \leq 0.01$), ***($p < 0.001$)
DF = Degrees of Freedom
SUM SQ = Sum of Squares
MEAN SQ = Mean Square

Scrapers

Scrapers were rare, and therefore relative abundance showed few differences. Although there was a significant difference in scraper abundance between pre- and post-treatment (**Table 12**), the difference is less than 0.1% and likely represents sampling bias more than a true difference.

TABLE 12
SUMMARY ANOVA TABLE FOR THE RELATIVE ABUNDANCE OF PREDATORS

Source	Df	Sum Sq	Mean Sq	F-value	P-Value
Scrapers					
Waterbody	1	0.000	0.000	0.164	0.686
Period	1	0.021	0.021	8.720	0.004 ***
Site	8	0.025	0.003	1.295	0.256
Habitat	1	0.000	0.000	0.086	0.770
Waterbody:Period	1	0.001	0.001	0.365	0.547
Waterbody:Site	2	0.002	0.001	0.512	0.601
Period:Site	8	0.029	0.004	1.495	0.169
Waterbody:Habitat	1	0.004	0.004	1.620	0.206
Period:Habitat	1	0.000	0.000	0.004	0.951
Site:Habitat	8	0.039	0.005	2.043	0.050 *
Waterbody:Period:Site	2	0.000	0.000	0.056	0.945
Waterbody:Period:Habitat	1	0.001	0.001	0.485	0.488
Waterbody:Site:Habitat	2	0.002	0.001	0.325	0.723
Period:Site:Habitat	8	0.038	0.005	1.985	0.057
Waterbody:Period:Site:Habitat	2	0.001	0.001	0.224	0.800
Residuals	94	0.227	0.002		

Notes:
Significance level: * ($p \leq 0.05$), ** ($p \leq 0.01$), ***($p < 0.001$)
DF = Degrees of Freedom
SUM SQ = Sum of Squares
MEAN SQ = Mean Square

Index of Biological Integrity

The adapted IBI shows the same trends generally observed in the individual metrics presented above. For many treatment sites, during the initial year post-treatment, the IBI drops before rebounding in the second year, and in the majority of treatment sites the IBI for the second year post-treatment was higher than pre-treatment conditions (**Figure 5**). However, none of these represent a statistically significant shift in IBI at any site, and the only significant differences seen are the IBI between treatment sites which varied without a distinguishable trend and habitat types (near-shore vs mid-channel) where the IBI mid-channel is lower on average (mean = 25.5) compared to near-shore (mean = 53.4) (**Table 13**).

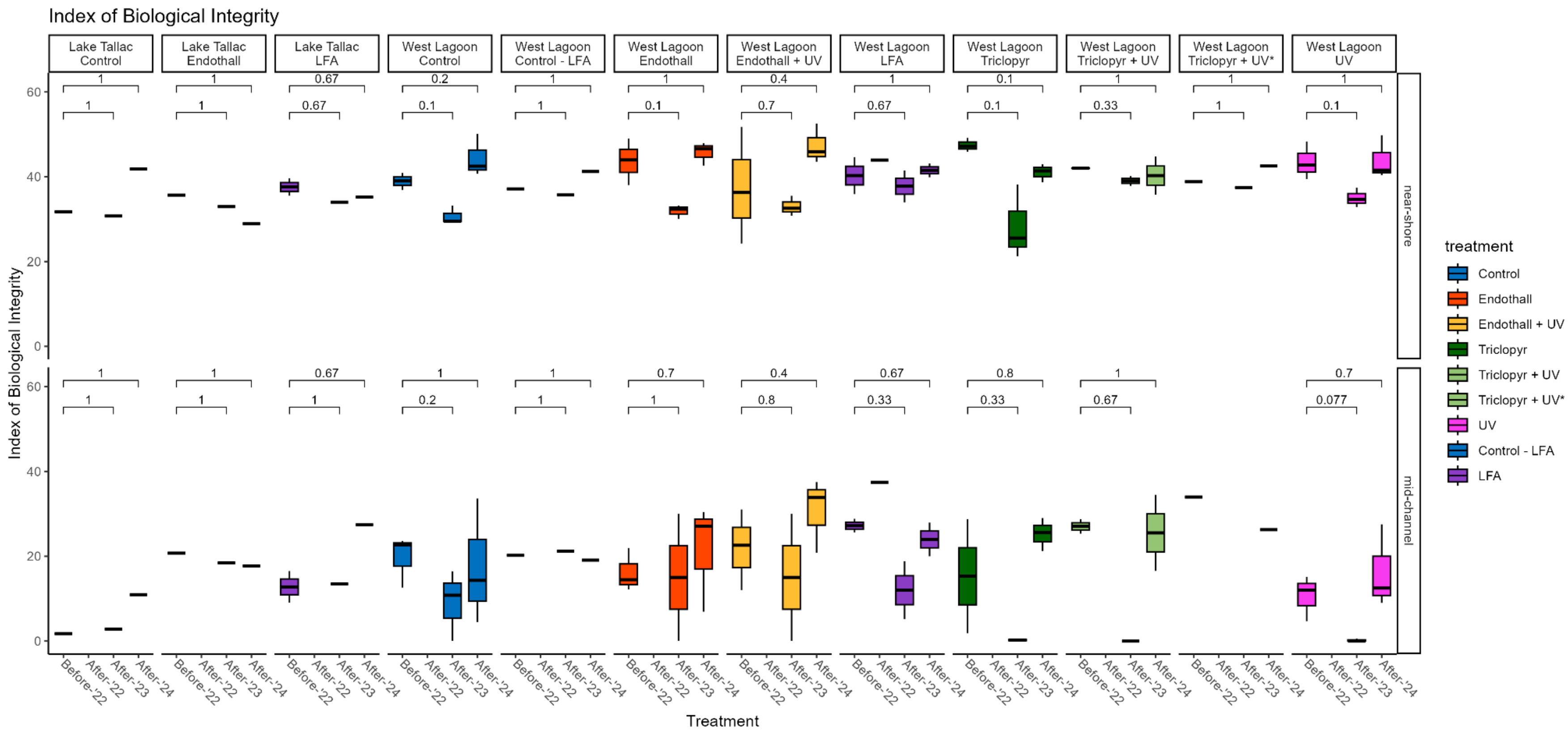

Figure 5

Cumulative IBI scores for each year, for each treatment group within each area, for each habitat type (mid-channel and near-shore). Bars without statistical comparisons above consist of single samples and are therefore not statistically compared. Numbers with brackets indicate the *p*-value of Wilcoxon tests between the Pre-Treatment year and each Post-Treatment year for years with more than one sample, where *p*< 0.001 is significant. Triclopyr + UV* = Site 12 which did not receive the intended UV treatments.

TABLE 13
SUMMARY ANOVA TABLE FOR THE INDEX OF BIOLOGICAL INTEGRITY

Source	Df	Sum Sq	Mean Sq	F-value	P-Value
Waterbody	1	448.598	448.598	5.147	0.026 *
Period	1	129.088	129.088	1.481	0.227
Site	8	1,073.365	134.171	1.539	0.154
Habitat	1	16,144.340	16,144.340	185.231	0.000 ***
Waterbody:Period	1	71.067	71.067	0.815	0.369
Waterbody:Site	2	25.288	12.644	0.145	0.865
Period:Site	8	231.781	28.973	0.332	0.951
Waterbody:Habitat	1	2.300	2.300	0.026	0.871
Period:Habitat	1	6.256	6.256	0.072	0.789
Site:Habitat	8	945.219	118.152	1.356	0.226
Waterbody:Period:Site	2	66.351	33.175	0.381	0.684
Waterbody:Period:Habitat	1	26.853	26.853	0.308	0.580
Waterbody:Site:Habitat	2	148.079	74.040	0.849	0.431
Period:Site:Habitat	8	260.458	32.557	0.374	0.932
Waterbody:Period:Site:Habitat	2	63.668	31.834	0.365	0.695
Residuals	94	8,192.833	87.158		

Notes:
Significance level: * ($p \leq 0.05$), ** ($p \leq 0.01$), ***($p < 0.001$)
DF = Degrees of Freedom
SUM SQ = Sum of Squares
MEAN SQ = Mean Square

INTERPRETATION

The BMI response to the CMT is varied, but generally represents a trend toward “recovery” as defined within APAP Amendment 1 for BMI: “lessening trend in tolerant species, showing conditions in lagoons had become less degraded and able to support more diverse species.” As expected, immediately after initial application, species richness showed a decline. However, in subsequent sampling events species richness, both overall and among sensitive EPT taxa is statistically equivalent to pre-application conditions, and in some cases, overall richness appears to have increased. Additionally, the relative abundance of the most dominant taxa is also statistically equivalent pre- and post-treatment, indicating that treatments have not had a lasting negative impact on diversity and diversity may be improving in some treatment sites where post-treatment abundances of dominant taxa are lower. The multi-metric IBI showed similar signs of recovery with some IBI index values scoring higher post-treatment than pre-treatment.

The general decrease in average tolerance across most sites between pre- and post-treatment, though not significant, may indicate that the abundances of tolerant taxa may be decreasing while intolerant taxa may be becoming more prevalent. This could indicate an improvement in water quality post-treatment. Changes in the trophic diversity at sites also point to a potentially beneficial shift. Increases in gatherer abundances juxtaposed by an overall decrease in filterer abundances may indicate that less suspended fine particulate organic matter (FPOM) is present in the water column and is instead settling and accumulating on the benthos where it can be consumed by gatherers, which may also result in improved water clarity. Continued monitoring may continue to show further improvements to the BMI community post-treatment.

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SUMMARY TABLES

West Lagoon

	Control					
	mid-channel			near-shore		
	Before	After		Before	After	
	2022	2023	2024	2022	2023	2024
Sites	16, 17, 18	16, 17, 18	16, 17, 18	16, 17, 18	16, 17, 18	16, 17, 18
Richness	10	8	10	30	23	40
EPT Richness	0	0	0	5	1	7
%-Dominant Taxa	25%	17%	23%	12%	17%	23%
Dominant Taxa	Nemata	Oligochaeta	Oligochaeta	Hyalella	Ostracoda	Micropsectra
Average Tolerance	6.4	7.9	7.3	7.3	7.2	6.9
%-Scrapers	4%	10%	0%	1%	1%	1%
%-Predators	18%	31%	4%	27%	9%	14%
%-Filterers	14%	0%	2%	23%	23%	7%
%-Gatherers	25%	55%	85%	39%	46%	67%
%-Other	39%	3%	10%	11%	21%	10%

	Control - LFA					
	mid-channel			near-shore		
	After			After		
	2022	2023	2024	2022	2023	2024
Sites	**7**	**7**	**7**	**7**	**7**	**7**
Richness	12	8	8	23	34	31
EPT Richness	1	0	0	3	3	2
%-Dominant Taxa	36%	33%	20	43%	22%	20%
Dominant Taxa	Psectrocladius	Chironomus	Chironomus, Oligochaeta	Chydoridae	Paratanytarsus	Hyalella
Average Tolerance	9.0	7.5	7.8	7.9	6.8	7.5
%-Scrapers	0%	0%	0%	9%	2%	6%
%-Predators	15%	8%	20%	18%	12%	16%
%-Filterers	3%	8%	10%	4%	28%	8%
%-Gatherers	78%	75%	70%	65%	54%	66%
%-Other	4%	8%	0%	4%	4%	3%

	Endothall					
	mid-channel			near-shore		
	Before	After		Before	After	
	2022	2023	2024	2022	2023	2024
Sites	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3
Richness	13	3	13	30	19	38
EPT Richness	1	0	0	3	1	3
%-Dominant Taxa	28%	50%	43%	16%	32%	10%
Dominant Taxa	Paratanytarsus	Oligochaeta, Chironomus	Ostracoda	Hyalella	Oligochaeta	Chydoridae
Average Tolerance	7.1	7.5	7.2	7.2	6.6	6.9
%-Scrapers	0%	0%	0%	4%	0%	1%
%-Predators	28%	0%	5%	21%	19%	17%
%-Filterers	36%	0%	0%	9%	20%	4%
%-Gatherers	28%	100%	79%	61%	53%	66%
%-Other	8%	0%	16%	5%	9%	13%

	Endothall + UV					
	mid-channel			near-shore		
	Before	After		Before	After	
	2022	2023	2024	2022	2023	2024
Sites	10, 11, 15	10, 11, 15	10, 11, 15	10, 11, 15	10, 11, 15	10, 11, 15
Richness	9	2	13	29	19	40
EPT Richness	0	0	0	5	0	7
%-Dominant Taxa	61%	75%	16%	13%	24%	14%
Dominant Taxa	Nemata	Chironomus	Ostracoda	Ostracoda	Oligochaeta	Chydoridae
Average Tolerance	5.4	8.8	6.3	7.4	6.3	6.4
%-Scrapers	0%	0%	0%	2%	0%	0%
%-Predators	4%	0%	5%	26%	8%	13%
%-Filterers	2%	0%	5%	11%	14%	14%
%-Gatherers	26%	100%	62%	49%	65%	59%
%-Other	67%	0%	28%	12%	13%	14%

	LFA							
	mid-channel				near-shore			
	Before	After			Before	After		
	2022 (Spring)	2022 (Fall)	2023	2024	2022 (Spring)	2022 (Fall)	2023	2024
Sites	25, 26	25	25, 26	25, 26	25, 26	25	25, 26	25, 26
Richness	10	14	12	8	30	29	37	34
EPT Richness	0	0	0	0	3	4	5	6
%-Dominant Taxa	41%	41%	23%	23%	21%	17%	41%	46%
Dominant Taxa	Nemata	Ostracoda	Oligochaeta	Chydoridae	Paratanytarsus	Chydoridae	Chydoridae	Chydoridae
Average Tolerance	6.1	7.0	8.0	7.3	6.8	7.7	6.6	6.9
%-Scrapers	0%	2%	0%	8%	1%	9%	0%	2%
%-Predators	19%	6%	30%	31%	44%	19%	8%	9%
%-Filterers	6%	2%	7%	8%	24%	14%	12%	6%
%-Gatherers	16%	68%	63%	54%	29%	56%	74%	82%
%-Other	59%	23%	0%	0%	2%	2%	6%	2%

	Triclopyr					
	mid-channel			near-shore		
	Before	After		Before	After	
	2022	2023	2024	2022	2023	2024
Sites	5, 8, 9	5, 8, 9	5, 8, 9	5, 8, 9	5, 8, 9	5, 8, 9
Richness	7	2	10	31	24	32
EPT Richness	0	0	0	5	1	3
%-Dominant Taxa	25%	50%	34%	10%	15%	21%
Dominant Taxa	Oligochaeta, Gyraulus	Ablabesmyia, Psectrocladius	Nemata	Ceratopogoninae	Oligochaeta	Oligochaeta
Average Tolerance	7.0	9.0	6.1	6.8	6.7	7.0
%-Scrapers	25%	0%	3%	5%	0%	1%
%-Predators	25%	50%	11%	51%	16%	25%
%-Filterers	13%	0%	0%	5%	11%	5%
%-Gatherers	38%	50%	48%	32%	59%	68%
%-Other	0%	0%	37%	7%	14%	2%

	Triclopyr + UV					
	mid-channel			near-shore		
	Before	After		Before		After
	2022	2023	2024	2022	2023	2024
Sites	13, 14	13, 14	13, 14	13, 14	13, 14	13, 14
Richness	5	3	9	27	22	33
EPT Richness	0	0	0	3	1	4
%-Dominant Taxa	53%	57%	23%	19%	23%	15%
Dominant Taxa	Nemata	Parachironomus	Ostracoda	Hyalella	Oligochaeta	Ostracoda
Average Tolerance	5.4	10.0	6.8	6.9	6.1	7.3
%-Scrapers	0%	0%	0%	3%	0%	1%
%-Predators	9%	57%	14%	32%	32%	20%
%-Filterers	6%	0%	0%	6%	10%	2%
%-Gatherers	24%	43%	64%	59%	53%	69%
%-Other	62%	0%	23%	1%	6%	9%

	Triclopyr + UV* – Site 12					
	mid-channel			near-shore		
	Before	After		Before		After
	2022	2023	2024	2022	2023	2024
Sites	12	12	12	12	12	12
Richness	6	0	10	21	18	25
EPT Richness	0	0	0	2	1	0
%-Dominant Taxa	78%	NA	41%	43%	58%	25%
Dominant Taxa	Nemata	NA	Nemata, Ostracoda	Hyalella	Oligochaeta	Chydoridae
Average Tolerance	5.3	NA	6.5	7.8	5.5	6.8
%-Scrapers	0%	NA	0%	5%	1%	0%
%-Predators	9%	NA	3%	32%	13%	24%
%-Filterers	0%	NA	2%	4%	6%	2%
%-Gatherers	4%	NA	55%	58%	67%	69%
%-Other	87%	NA	41%	0%	14%	4%

	UV					
	mid-channel			near-shore		
	Before	After		Before	After	
	2022	2023	2024	2022	2023	2024
Sites	22, 23, 24	22, 23, 24	22, 23, 24	22, 23, 24	22, 23, 24	22, 23, 24
Richness	6	5	12	27	27	44
EPT Richness	0	0	0	4	1	5
%-Dominant Taxa	25%	30%	23%	14%	18%	9%
Dominant Taxa	Parachiron-omus	Parachiron-omus	Nemata, Ostracoda	Hyalella	Oligochaeta	Micropsectra
Average Tolerance	8.3	9.4	6.8	7.3	6.8	7.1
%-Scrapers	0%	0%	0%	4%	1%	2%
%-Predators	44%	60%	3%	33%	9%	21%
%-Filterers	38%	0%	1%	13%	33%	9%
%-Gatherers	19%	40%	65%	46%	49%	64%
%-Other	0%	0%	32%	5%	7%	4%

Lake Tallac

	Control					
	mid-channel			near-shore		
	Before	After		Before	After	
	2022	2023	2024	2022	2023	2024
Sites	20	20	20	20	20	20
Richness	3	3	4	22	17	24
EPT Richness	0	1	0	1	1	3
%-Dominant Taxa	50%	65%	44%	24%	43%	33%
Dominant Taxa	Ablabesmyia	Ablabesmyia	Oligochaeta	Caenis	Caenis	Oligochaeta
Average Tolerance	7.8	7.8	7.3	6.9	6.8	6.8
%-Scrapers	0%	0%	0%	1%	0%	1%
%-Predators	50%	70%	33%	37%	12%	19%
%-Filterers	0%	0%	11%	10%	18%	12%
%-Gatherers	50%	30%	56%	51%	66%	67%
%-Other	0%	0%	0%	0%	4%	1%

	Endothall					
	mid-channel			near-shore		
	Before	After		Before	After	
	2022	2023	2024	2022	2023	2024
Sites	19	19	19	19	19	19
Richness	4	4	8	20	20	21
EPT Richness	0	0	0	1	1	2
%-Dominant Taxa	57%	25%	73%	18%	36%	26%
Dominant Taxa	Ablabes-myia	Parachiro-nomus, Paratany-tarsus, Ostracoda, Oligochaeta	Oligochaeta	Tanytarsus	Oligochaeta	Coena-grionidae
Average Tolerance	7.5	7.3	6.0	6.7	6.3	7.9
%-Scrapers	0%	0%	0%	2%	1%	1%
%-Predators	57%	25%	6%	35%	9%	35%
%-Filterers	0%	25%	2%	18%	22%	13%
%-Gatherers	43%	50%	92%	46%	56%	50%
%-Other	0%	0%	0%	0%	11%	1%

	LFA							
	mid-channel				near-shore			
	Before	After			Before	After		
	2022	2022	2023	2024	2022	2022	2023	2024
Sites	27	27	27	27	27	27	27	27
Richness	5	6	7	15	20	29	33	38
EPT Richness	0	0	0	0	1	3	3	7
%-Dominant Taxa	39%	37%	28%	16%	16%	21%	17%	17%
Dominant Taxa	Parachironomus	Ostracoda	Tanytarsus	Ostracoda	Ceratopogoninae	Chironomus	Dicrotendipes	Micropsectra
Average Tolerance	8.1	7.7	7.8	7.6	7.1	7.5	7.3	7.0
%-Scrapers	0%	0%	0%	0%	1%	14%	1%	5%
%-Predators	56%	32%	38%	26%	38%	23%	34%	22%
%-Filterers	17%	11%	28%	8%	13%	2%	14%	10%
%-Gatherers	28%	53%	34%	63%	46%	55%	48%	61%
%-Other	0%	5%	0%	3%	3%	5%	2%	2%