A Longterm Evaluation of the Effects of TFM on Non-target Fish and Macroinvertebrates In Lewis Creek, Vermont

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INTRODUCTION

An Aquatic Nuisance Control Permit was granted by the Vermont Department of Environmental Conservation (DEC) to the Vermont Department of Fish and Wildlife to use the lampricide, TFM in Lewis Creek for sea lamprey control in March 1990. This permit allows two, evenly-spaced applications over a period of five years. Condition 33 of the permit calls for a long-term evaluation of non-target impact to be conducted following the first treatment. This report presents the results of 2-3 years post-treatment data

from fish and macroinvertebrate communities collected from one to two locations on Lewis Creek.

This study was designed and carried out by the VTDEC, which also conducted the short term evaluation (Langdon and Fiske 1991).

METHODS

The short-term impact study utilized a "before-after" and "above-below" approach in determining the effect on ambient fish and macroinvertebrate communities downstream of the TFM application point. Biological data were collected at three sites for fish and six sites for macroinvertebrates. Samples were collected one and/or two years and again 1-10 days prior to application. Sampling was then conducted ten days following the application.

Macroinvertebrates

The short term study showed no adverse effects on the overall structure and function of the macroinvertebrate communities from any of the habitat types of Lewis Creek exposed to the TFM treatment. One of five species known to be sensitive to TFM (the caddisfly *Chimarra* spp.) in the riffle habitat areas declined significantly ($p<0.002$). The decline was most pronounced (97%) at the lower riffle site 3. Five taxa in the lower part of the river were also monitored because of their sensitivity to TFM. Of these only the mayfly *Hexagenia limbata* declined significantly ($p<.05$) by 61 percent in the Streambank Habitat area site 4. Long term monitoring was continued at these two sites to document the length of time needed for these two TFM sensitive species to recover and to monitor the longterm community integrity of a stream scheduled to receive additional TFM treatments. In this report site 3 will be referred to as station 3.5 and site 4 as station 0.5. These numbers refer to the stream mile where each site is located upstream from the mouth. Macroinvertebrates were sampled at station 3.5 using a standard timed kick net method and at station 0.5 using a six inch Ekman Dredge as outlined in Langdon and Fiske (1991). Both sites have been sampled on a yearly basis in the early fall from 1988 to 1993. In 1990 the sites were sampled twice, one day before and then again ten days after the TFM application. The community-level biometrics and the TFM-sensitive species data for both sites are presented in tables in the text. The raw data for both sites by year and replicate is attached as appendix 1.

Fish

Since there were no population-level effects observed for the fish community during the short-term study, no long-term effects were anticipated, considering the short exposure period to TFM (less than one day). Consequently, only the fish community at station 3.7 (station T-2 in the short-term study) was selected to monitor over the long term. The site was sampled by electro-fishing using the methods presented in Langdon and Fiske (1991). Data were collected once during 1991 and again in 1992. A collection was to have taken place in 1993, but scheduling difficulties prohibited sampling within the proper time period. Both 1991 and 1992 samples were collected within the same range of dates (late Sept.-Early Oct.) as were the first three samples reported in the short-term study. The present discussion will include data from 1989 and 1990b (before treatment) and 1990a (after treatment).

RESULTS AND DISCUSSION

Macroinvertebrates

The macroinvertebrate community metrics for site 3.5 and the density of the sensitive taxa are presented in Table 1. The Index of Biotic Similarity - B (Pinkham and Pearson 1976) was used to track the overall similarity in percent composition of the dominant (>3.4%) taxa at station 3.5 over time and is presented in Table 2. The data show no change in the community metrics over the six year period sampled.

Numbers of the sensitive caddisfly Chimarra spp., which declined 97% after the treatment, recovered to densities within those found during the three pretreatment years one year following treatment and have remained consistent for the last three years sampled. A mean B was determined for each of three contrast associations by comparing all combinations of years within a contrast association, the contrasts being: 1) only dates sampled before the treatment, 2) dates sampled before to those after treatment and 3) only dates sampled after the treatment. The mean B when comparing the 3 years before the treatment only was 0.45. Mean B's showed the community to be slightly more similar (0.52) between the years before vs the years after the treatment. Since the treatment the B similarity has been consistent with an average of 0.51 between all 4 years after the treatment. In conclusion ,the similarity B of the macroinvertebrate community from one year to the next based on the density of it's dominant species has remained unchanged since 1988, being about 50% similar.

Table 1 . Macroinvertebrate community metrics over a six year period from station 3.5 (riffle habitat) on Lewis Creek, Vt. Also included is the mean density of the TFM sensitive taxon Trichoptera Chimarra spp.

Date	1988	1989	1990 B	1990 A	1991	1992	1993
Density/2min KN	1898	3967	4025	4569	2526	2517	2244
Species Richness	41	50.5	67	54.5	47	44.1	42.5
EPT Richness	21.5	25.3	25.6	27.8	24.5	23.1	20.5
Bio Index (0-5)	1.95	2.10	2.26	2.18	1.77	1.77	2.22
Diversity	3.87	4.52	4.56	4.35	4.36	4.15	4.34
EPT/EPT&Chiro	0.95	0.87	0.84	0.78	0.96	0.88	0.69
% Dominant Taxa	20	16	24	19	24	19	19
Density Chimarra sp	36	191	88	3*	45	65	56

* indicates a significant difference (p<.05) compared to all other years sampled using the Kruskal-Wallace statistic and the Student Newmens-Keuls test.

Table 2. Mean Index of Biotic Similarity (B) values between year contrast associations of the dominant genera at station 3.5.

Contrast Associations	Before vs Before	Before vs After	After vs After
Mean B*	0.45	0.52	0.51
Range	0.39-0.49	0.41-0.62	0.42-0.65

* A mean B value is generated for each contrast association by comparing all possible combinations of years within a particular contrast association.

The macroinvertebrate community metrics and the density of the sensitive species from site 0.5 (lower river-clay bank habitat) are presented in Table 3. For the year following the TFM treatment no community level changes occurred. In the second and third years after the treatment the taxa richness increased at the site significantly ($p<0.05$) by about a third from an average of 15.5 in the years previous to 20.8 in 1992 and 23.2 in 1993. The density increased significantly ($p<05$) in 1993 by about 120% from an average of about 5,428/m2 over the previous five years to about 12,130/m2 in 1993. The above increases in both richness and density may indicate a trend toward increased enrichment of the stream. At least part of the increase in richness and density appears to be due to increases in the fingernail clam Pisidium spp. and the insect order Diptera, in particular the midges and no-seeums Chironomidae and Ceratopogonidae. At the present time the trend toward increased richness and density is not detrimental to the overall community structure or function.

As reported in Langdon and Fiske (1991) the sensitive taxa Hexagenia sp. significantly ($p<0.05$, Mann Whitney-U paired statistic) decreased in density by about 60% from densities measured immediately before the TFM application. This reduction was directly attributable to the treatment, as determined from field observation of dead nymphs in the lower river 1-2 days after the treatment. The Hexagenia sp. population rebounded one year later to the highest population (273/m2) recorded in the six years of monitoring. The 1991 Hexagenia sp. population was in fact significantly ($p<05$) higher than that reported in 1989 (115/m2),1990a (70/m2), and 1993 (85/m2). When all years are compared the 1991 high population is the only year significantly different from any other year indicating that in the long term the population decrease observed in 1990a left the Hexagenia sp. population within the longterm expected population levels. If, however, the population was in a natural low period, a TFM treatment could potentially decrease the Hexagenia sp. population to a point where it may need several years to recover and put it at a greater risk to naturally occurring population stressors. The 1993 data show the Hexagenia sp. to be low in density. If a treatment were to have occurred in 1993 the population probably would have been significantly reduced to below the documented long term norm putting it at greater risk to natural population fluxes. As a result continued monitoring of the Hexagenia sp population is recommended for the duration of the experimental TFM program.

The Trichoptera (caddisfly) Phylocentropus sp. showed no effect from the TFM treatment when comparing the population levels before and after treatment as reported in Langdon and Fiske (1991). The longterm monitoring data show that the 1991 population was significantly ($p<05$) lower than in 1989 and 1990 before and after the treatment but not lower than 1988, 92, or 93. The 1988 and 1992 populations were also lower than that in 1990 before and after the treatment. These data show that for some unknown reasons the caddis Phylocentropus sp. were at a low point in 1991, and somewhat depressed in 1988 and 1992. The TFM treatment may have played a role in the low 1991 population however it is unclear how since the short term study clearly demonstrated no direct effect on the population.

The fingernail clam Pisidium spp. population has shown no short or longterm detrimental effects from the TFM treatment. In 1993 the population showed a significant ($p<0.05$) increase in density compared to several past years (1990b,1991,1992). Pisidium spp are generally tolerant toward moderate amounts of enrichment, benefitting from the increase in particulate matter to filter. Their increase in density, along with the overall increase in both community richness and density, may point toward a general increase in enrichment of Lewis Creek.

Table 3. Macroinvertebrate community metrics over a six year period from station 4 (Clay bank habitat) on Lewis Creek, Vt. Also included is the density of the TFM sensitive taxa.

Date	1988	1989	1990 B	1990 A	1991	1992	1993
Density/m2	4813[93]	5070[93]	4250[93]	5215[93]	5465[93]	7755[93]	12130
Richness	14.3[92,93]	16[92,93]	15[92,93]	16.8[92,93]	14.4[92,93]	20.8	23.2
Diversity	3.10	3.30	3.18	3.30	2.89	3.21	3.39
% Dominance	26	19	21	19	26	27	25
Den. <u>Hexagenia</u> sp.	137.5	115[91]	180	70[91]	273	178	85[91]
Den. <u>Phylocentropus</u>	25[90a&b]	310	485	505	16[89,90a&b]	85[90a&b]	170
Den. <u>Pisidium</u> spp.	587.5	760	290[93]	660	279[93]	217[93]	1674

Superscripts indicate years that are significantly different from each other at $p<.05$ using the Kruskal-Wallace and the Student-Newman-Keuls test.

The above data from both a riffle type habitat and a lower river depositional clay bank area demonstrate that the TFM treatment of Lewis Creek has had "no undue adverse effect" on the longterm integrity of the macroinvertebrate communities from Lewis Creek. The data also show that the treatment did reduce populations of two sensitive species immediately after the treatment. Longterm monitoring, however, has documented that both species recovered one year later. The longterm data on these sensitive species points out that their populations could be more severely stressed if a treatment were to occur in a year when their populations are already naturally low. The longterm data also demonstrate that the riffle community of Lewis Creek is in good- excellent condition compared to the DEC statewide data base and remarkably stable from year to year in terms of the community biometrics. The lower claybank community has shown a trend toward increased richness and density the last two years indicating a possible influence of increased enrichment in the lower river, not related to the treatment.

The continued monitoring of these two communities in Lewis Creek will increase our understanding of natural population fluxes as well as document any long term shifts in community structure the may point toward a change in environmental quality.

FISH

Data from the fish community parameters of species richness, Vermont Index of Biotic Integrity (VTIBI) and total density information are presented in Table 4 . Species richness was 17-18 for the first three samples (1989-1990a) which encompassed the two pre-treatment collections and the first post-treatment collection. The 1991 and 1992 samples yielded 14 species each. There were six dominant species which were observed in all five collections accounting for 95-98% of the catch size. These were tesselated darter, smallmouth bass, common shiner, longnose dace, logperch and white sucker. Six minor species (<0.4% of total) including largemouth bass, brown bullhead, Northern pike, rainbow trout, silvery minnow and burbot were recorded only in the two pretreatment samples. Available data contained in the VTDEC streams database shows that the occurrence of minor species in collections is temporally sporadic in the absence of significant human impact and only dominant species persist in samples year to year. The observance of a minor species in a sample is highly dependent on sampling error (Pearson and Pinkham 1992) and studies from the literature examining fish population persistance and stability often ignore minor species in their investigations, eg. Moyle and Vondracek 1985 and Mattews et al.1988. Since most species in this group are considered moderately resistant to TFM their absence can be mostly attributed to natural distributional qualities and sampling error. Species observed only in <u>post</u>-treatment samples were sand shiner, rosyface shiner and fallfish. Copies of site data sheets are included in Appendix 2.

Table 4 . Population Parameters for the Fish Community at Lewis Creek 3.7 Before and After the Application of TFM.

Parameters	1989	1990-	1990-after	1991	1992

OR

		Before			
Species Richness	17	18	17	14	14
VTIBI[1]	39 (g-exc)	39 (g-exc)	39 (g-exc)	39 (g-exc)	41 (exc)
Total Density[2]	44.8	83.1	37.7	46.1	50.3
Total Density[3]	68.7	134.8	80.2	75.3	82.1[4]

1. VTIBI values range from 9(very poor) to 45(excellent).
2. Density is measured in numbers of fish collected in the first electro-fishing pass converted to #s/100m².
3. Density in #s/100m² from fish collected from two electrofishing passes
4. Value estimated from previous ratios of pass two numbers to total numbers.

The VTIBI is an integrative index of fish population health. This index is used by the VTDEC
to determine compliance with State Water Quality Standards. VTIBI values for site 3.7 consistently indicated good to excellent and excellent community health throughout the five sampling occasions. Values were 39 (out of a possible 45) for the first four dates and 41 for the 1992 collection.

Total population density, as expressed as numbers collected in two electrofishing runs converted to numbers/100^2, were quite consistent year to year with the exception of 1990b, which was nearly twice the 1990a sample. This marked discrepancy in density between samples taken within three weeks of each other (before and after the treatment) is accounted for in the short term by poor sampling conditions experienced during the 1990a collection and not to effects from TFM. It is likely that if conditions had been more favorable for sampling during the post-treatment effort that numbers would have been comparable between the two 1990 dates.

Two additional parameters used to evaluate community response are the Index of Biotic Similarity - B (Pinkham and Pearson 1976) and the Coefficient of Concordance - W (Tate and Clelland 1957). Both metrics address population structure, principally species occurrence and density. B measures community similarity between pairs of samples while W quantifies the temporal consistency of the population structure at a single site over time. Table 5 shows mean B and W values for station 3.7. and provides an explanation of the scoring.

Mean B values were generated by contrasting all possible combinations of pairs for a particular association. The first association, background similarity-Lewis Creek is the measure of "normal" variation in the absence of perturbation, is expressed by the resultant value from the comparison of 1989 vs 1990b (before TFM treatment). This value was 0.36. Values lower than this would indicate less similarity between samples with the opposite being true for higher values. Another measure of background similarity was derived from the mean from five other sites on different rivers (0.43). Both values will be used to represent the level of variation under non-impacted conditions. The third application is the short-term assessment produced by the mean of 1989 vs 1990a and 1990b vs 1990a. This value is 0.48 which shows greater similarity between before-after (short-term) populations than between the two before samples (background). Finally, the long-term application was expressed by computing the mean B of the following contrasts: 1989 vs 1991, 1989 vs 1992, 1990b vs 1991 and 1990b vs 1992. The mean of these contrasts is 0.56. This indicates 1) that over the period sampled, community similarity in Lewis Creek was greater than the mean from other unimpacted river sites and 2) that similarity was also higher between before-after (long-term) populations than between the two pre-treatment collections. These results imply that no observable

Table 5. Mean Index of Biotic Similarity Values and Coefficient of Concordance for Lewis Creek 3.7 for the Five Sampling Events.

Metric	Test	Value
B	Background Similarity - (89 vs 90b)	0.36
	Background Similarity - (five other sites)	0.43
	Short-Term Effect - (89 vs 90a and 89 vs 90b)	0.48
W	All Dates	0.92
	Five Other Sites	0.82

1. The Index of Biotic Similarity (Pinkham and Pearson 1992) was modified by weighing individual species according to their relative density in the population. Values range from 0 - total dissimilarity of contrasted samples, to 1.0 - total dissimilarity. Index values in this column were calculated by contrasting the density of each species which comprised over 1% of the population.

2. The Coefficient of Concordance (Tate and Clelland 1957) analyzes species ranks to measure community change over time. Values range from 0 - total change in species each year, to 1.0 - same species and same dominance rank each year. Communities that show higher values have a more temporally stable population structure.

community-wide effects (which would cause structural changes) were experienced over the time period 1989-1992. Community concordance (W) was higher at Lewis 3.7 for the period sampled than for other Vermont rivers. The W for site 3.7 was 0.92, compared to a mean from other sites of 0.82. The higher value suggests that the population at the Lewis Creek site was somewhat more structurally stable. Again, as with B, a community-wide impact from TFM would have caused a lower value, indicative of short and/or long-term change in population structure.

Fish community data collected at Lewis Creek station 3.7 thus far supports a declaration of "no undue adverse effect" to the fish community resulting from the application of TFM in 1990. The fish community of this site is of consistently good to excellent quality, and demonstrates good production and relatively high structural stability. The fish population at 3.7 will continue to be monitored throughout the experimental phase as called for by the original permit.

LITERATURE CITED

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