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BIOLOGICAL RESPONSE SIGNATURES

Indicator Patterns Using Aquatic Communities

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9 A Method for Assessing Outfall Effects on Great River Fish Populations: The Traveling Zone Approach

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CONTENTS

9.1 INTRODUCTION

The assessment of large and great river fish assemblages is complicated by sampling considerations (Simon and Sanders, 1999), metric development and testing (Simon, 1992; Simon and Emery, 1995; Simon and Stahl, 1998; Emery et al., 1999), and variation of individual IBI metrics (Gammon and Simon, 2000). Karr et al. (1985) indicated that large and great rivers of the United States do not receive adequate protection to conserve biological integrity. Great rivers are distinctive in that they are few in number, comprise the largest component of water resources (Vannote et al., 1980), and are disproportionately degraded (Karr et al., 1985; USEPA, 2000).

A pattern in community response to stress is used to determine biological integrity and ecological function (Karr and Dudley, 1981). It may be possible, by examining these discernable patterns in the response of a fish community, to determine certain biological response signatures

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of the effluent (Yoder and Rankin, 1995a). Shifts in a fish community in a given area may be used to pinpoint specific stressors on a great resource such as the Ohio River.

9.2 BACKGROUND

9.2.1 Ohio River Valley Water Sanitation Commission (ORSANCO) Approach

Point source effects on biological communities of great rivers are relatively unexplored aspects of pollution control and prevention. Due to the large volume of water great rivers move, effluent mixing zones are typically extremely short (ORSANCO and Ohio River Users Group, 1999). Therefore, any immediate effect of the outfall on organisms residing in the river is generally slight and hard to quantify. It is necessary to examine biological community response in the smallest possible segments that will consistently show impairment trends.

Standard electrofishing zones for the Ohio River are 500 m in length (ORSANCO, 2000). The response of the fish community to an impairment, however, is often constrained to the first 100 to 200 m, allowing the community to adequately recover over the remaining 300 m of the zone. Therefore, by relying on a 500-m zone length, it is nearly impossible to describe the indicator response caused by the outfall or other pollution source. A method was needed to reveal changes in community structure and function too subtle to be captured by standard techniques.

9.2.2 Upstream versus Downstream Studies

Historically, the accepted method of determining the effect of an outfall on a stream was to compare the impacted area to an upstream, unimpaired "reference" condition. This method can work well and may be very effective in determining the extent of an impairment, but it also has several drawbacks that researchers must consider. The upstream site must reflect what the unimpaired study area conditions should be. Researchers should consider the importance of changes in microhabitat features (i.e., substrate type, depth, stream morphology) within the study area and the upstream reference area, carefully matching these conditions as closely as possible. We account for this variability by conducting a detailed examination of the microhabitats of the outfall zone and matching that data closely at an upstream location.

Another limitation of the upstream/downstream comparison is multiple impairments. It is often difficult, particularly in large and great rivers, to find an upstream reference site that matches the habitat of a study area and is not impacted by another outfall. It is common also for the study area to be impacted by multiple dischargers. Isolating the effect of one particular effluent in an area where several outfalls exist within a 500-m segment of a great river can be very difficult with a typical upstream/downstream study. However, it is possible to detect changes in the biological communities at the site of each impairment using the traveling zone (T-zone) method.

9.2.3 Ohio EPA Area Degradation Values

The Ohio Environmental Protection Agency (Yoder and Rankin, 1995b) developed a tool for interpreting biological response to impairments using multimetric data. This tool, the area of degradation value (ADV), allows examination of the recovery of a biological community by estimating the degree of departure from a biocriterion along a longitudinal continuum. The longitudinal resolution can be enhanced by spacing the sampling sites closer together, but this resolution can be limited by the required length of the sample site. Given the standard 500-m zone sampled by ORSANCO on the Ohio River (ORSANCO, 2000), determining the recovery of the biological community within that 500 m using the ADV is not possible. However, a similar result is accomplished by using the traveling zone method to assess the data on a finer scale.

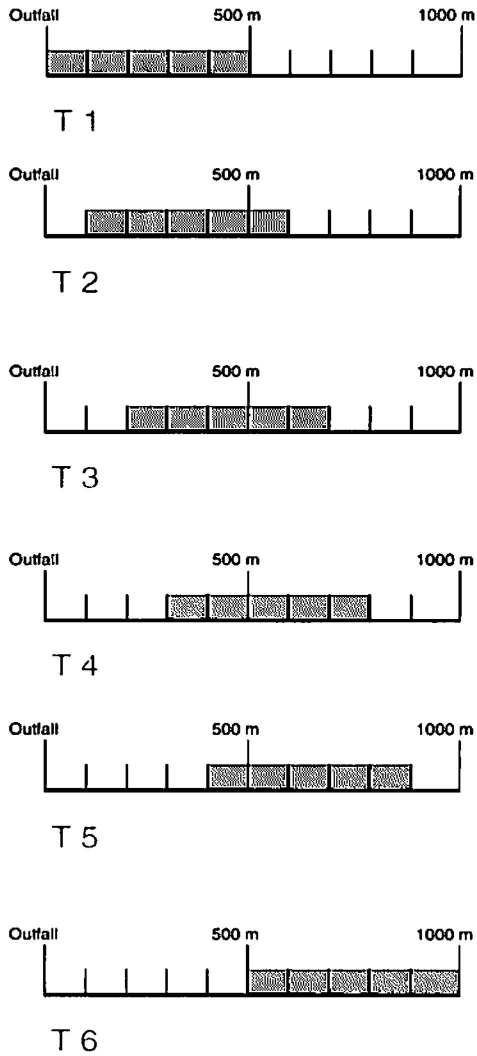

FIGURE 9.1 Diagram of the six traveling zones.

9.3 ASSESSMENT METHODS: THE TRAVELING ZONE APPROACH

9.3.1 Fish Methods

Sampling was conducted by boat night electrofishing as described by ORSANCO (2000). Two crews worked simultaneously to collect fish along 1000 m at each outfall. As one crew sampled the upper 500 m from the outfall downstream, the other crew started 500 m below the outfall and sampled the second half of the 1000-m zone. Each 500-m zone was sampled as a whole, with the fish from each 100-m segment recorded separately so that the data could be divided into ten 100-m segments and reconfigured for the T-zones (Figure 9.1).

9.3.2 Zone Design

The fish data were arranged so that the first T-zone (T1) consisted of the first five 100-m zones starting at the outfall. The second zone (T2) was the compilation of the data from the second to the sixth 100-meter zones, and so on downstream to T6, the last five 100-m zones.

9.3.3 Data Analysis

The six T-zones were created after the data were entered into a database and could be reconfigured. Thirteen fish metrics were calculated from data from these new 500-m zones (Emery et al., in preparation). The metrics were then graphed and appropriate statistical methods were applied to reveal trends observed from T1 to T6.

9.3.4 Water Chemistry

Chemical parameters were examined to determine the water quality of the effluent and track the downstream extent of the plume. Measurements of water temperature, pH, dissolved oxygen (DO), and conductivity were taken with a Hydrolab multiprobe water quality sampler at the outfall (0) and at each 100-m interval for the entire 1000 m. At point 0 and at every 100 m, bottom, middle, and surface measurements were taken at the shore, 15 m from shore, and 30 m from shore. This provided 54 data points per 500-m zone, which were used to reveal the water quality gradient along the zone.

9.4 RESULTS AND DISCUSSION

9.4.1 Defining Zones of Recovery

The traveling zone technique was successful in revealing gradients at the outfalls that were not stressed in the two normal concurrent 500-m zones. Differences in resolution between the T-zone method and the regular 500-m zones are shown in Figure 9.2. The percent of individuals as piscivores increased from the upper 500-m zone to the lower 500-m zone (Figure 9.2a). However, the T-zone approach (Figure 9.2b) better defined this increase. While looking at the two 500-m zones only, it can only be determined that the outfall no longer affects piscivores after 500 m. However, based on the T-zone approach, the effect may be diminished by T5, indicating that the effluent was diluted enough for the piscivore numbers to return to normal after 800 m.

This conclusion can be drawn because the last effluent effect on the percent of individuals as piscivores was seen at T4, which represents the compilation of data from the 500 m between 300 and 800 m. When evaluating the data from the last two 100-m zones, the percent of piscivores returned to expected conditions, suggesting an end of the effluent effect on the piscivore populations.

While Figure 9.2b shows an effluent that had an effect on a fish community for approximately 800 m, often the effect of an outfall on Ohio River fish does not extend that far downstream. Using 500-m zones, it is difficult to determine the distance an outfall effect may cover. Figure 9.3a shows an effluent that affected the centrarchid population within the first 500 m of the outfall. The effect appears diminished by the second 500-m zone, but it is impossible to determine precisely where the effect weakened. By examining the T-Zones at the same outfall (Figure 9.3b), it appears that the effect was only observed in the first 100 m of the outfall, since the number of centrarchids appears to have recovered by T2.

9.4.2 Gradient Patterns

The T-zone approach revealed gradients at most of the outfalls for each of the metrics examined (Figure 9.4). For example, the number of species steadily increased from the outfall to 1000 m downstream (Figure 9.4a). By looking only at T1 (upper 500 m) and T6 (lower 500 m), this gradient only appeared as a large jump. A similar trend was seen in the number of intolerant species as the effect began to level off after T4 (Figure 9.4b). The use of the T-zone method highlights the response to the stressor, provides a more robust sampling approach, and demonstrates responses that may have otherwise been overlooked.

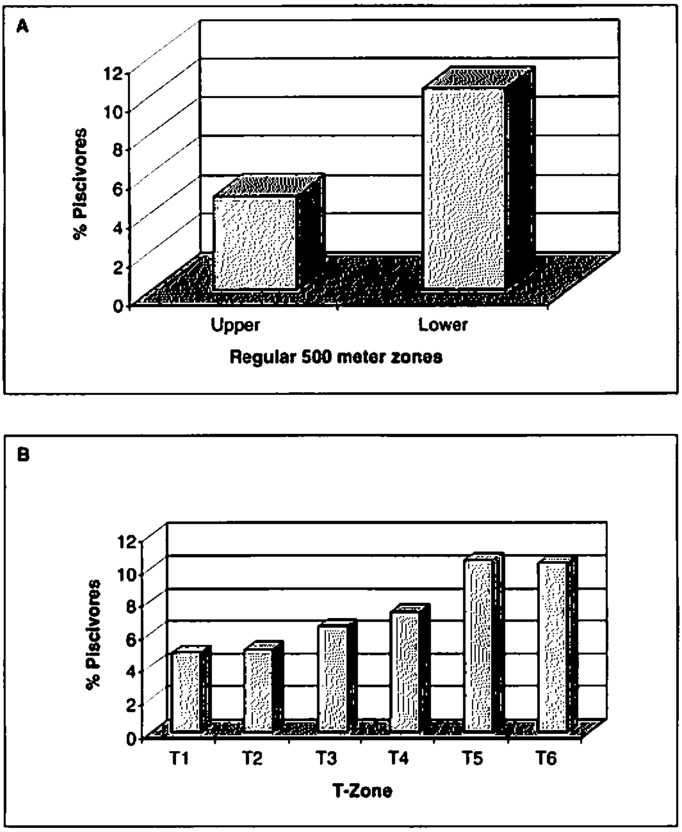

FIGURE 9.2 Resolutions of T-zones compared to those of two regular 500-m zones.

The T-zones showed the response gradient and validated the response of the multimetric index. By comparing the habitat and water chemistry parameters to the index score response for each T-zone, often a trend such as that illustrated in Figure 9.5 will brecome apparent. Figure 9.5 shows that as average surface temperature decreases from the outfall, a corresponding increase in multimetric index score was observed.

9.5 CONCLUSIONS

We developed a technique for evaluating fish community response, applicable for situations where the zone of impairment is too small to be adequately represented by a standard sized boat-electrofishing zone. By collecting data in 100-m increments along a continuous 1000 m, we are able to construct traveling zones or T-zones, each 500 m in length and incrementally 100 m further from the point of impact. This technique requires the sampling effort of two standard sized boat-electrofishing zones, but provides the equivalent of six standard sized boat-electrofishing zones. This overlapping technique provides 100-m resolution, increasing the ability to assess community response usually overlooked by standard 500-m zones.

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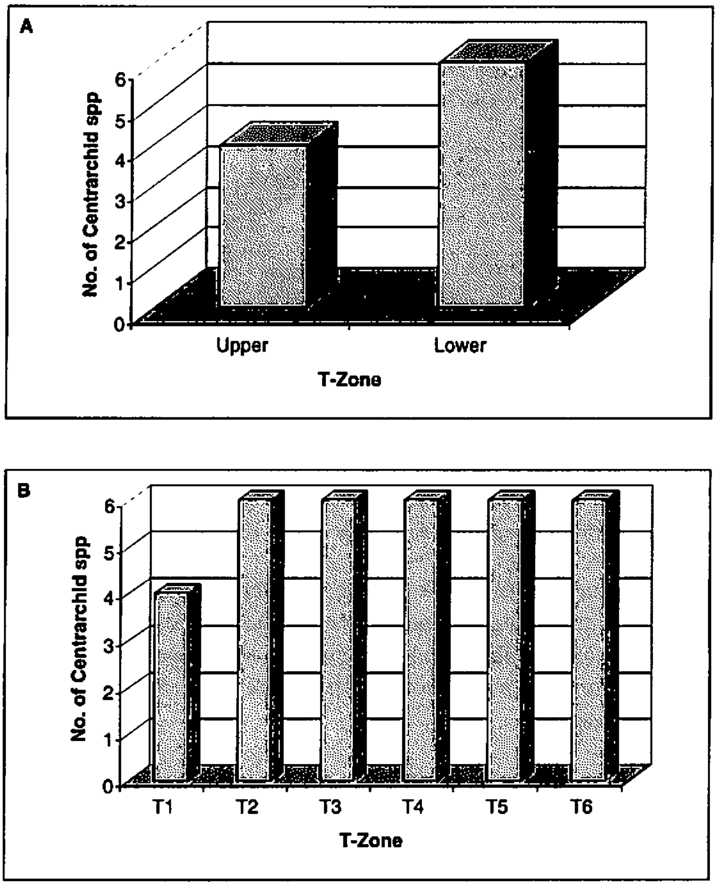

FIGURE 9.3 Resolutions of T-zones compared to those of two regular 500-m zones.

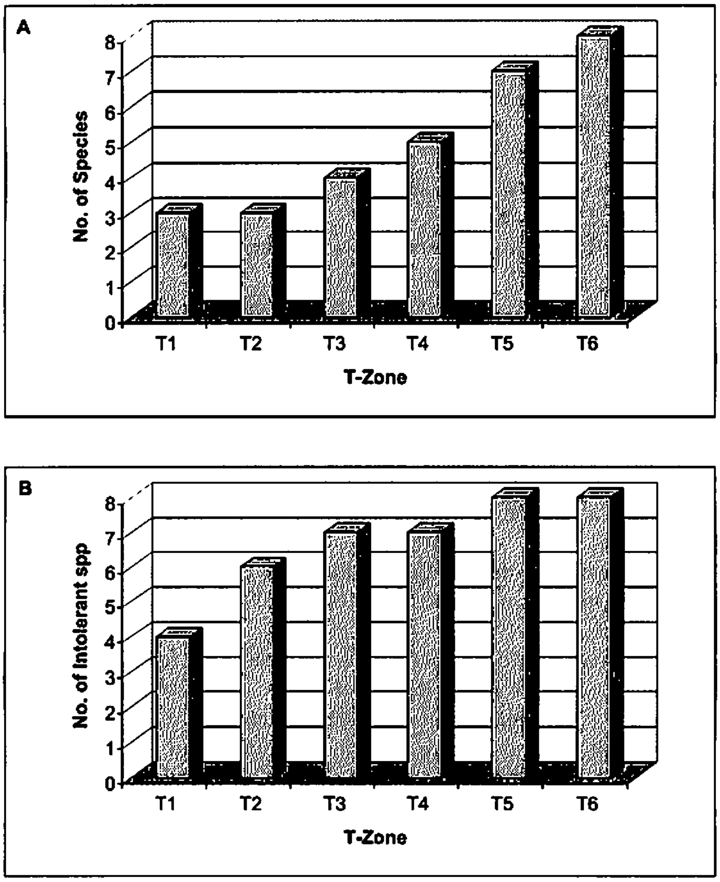

FIGURE 9.4 Examples of T-zone metric responses at two outfalls.

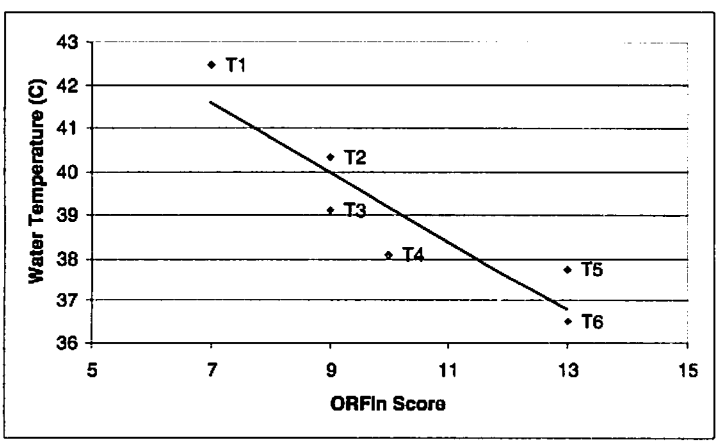

FIGURE 9.5 Surface water temperature versus ORFIn score at a thermal effluent.

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