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MACROINVERTEBRATE ABUNDANCE AND DIVERSITY
AS INFLUENCED BY SUBSTRATE SIZE IN
THE TRINITY RIVER

by

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January 1980

INTRODUCTION

Salmonid spawning in the Trinity River in Northern California has been seriously impaired by physical alterations of the habitat. Occasional high flows have flushed gravels from the riffles without replacement from upstream due to blockage by dams. Between flushing flows, decomposed granite sediment has accumulated in riffles and pools, followed by vegetative encroachment of the stream channel. These factors have contributed to the decline of the fish resources in the Trinity River.

Several mitigation measures have been employed in an effort to reverse the habitat degradation. Sediment sources are being identified and corrective measures initiated. Former pools are being reexcavated, while former riffles are being restored by removing present material and restocking with clean gravels of a size suitable for salmonid spawning. The effects of this riffle restoration on the aquatic macroinvertebrate community was examined by Boles (1979). The purpose of this present study was to further elucidate the relationship between substrate size and macroinvertebrate density and diversity in the Trinity River.

METHODS

A restored riffle located 5.0 km (3.1 mi) below Lewiston Dam on the Trinity River was chosen as the study area. The replaced gravels ranged in size from 2.5 to 10 cm (1 to 4 in). On April 17, 1979, gravels were removed to a depth of about 15 cm (6 in) from an area of about 21 m² (225 ft²) and replaced by medium cobbles of from 15 to 20 cm (6 to 8 in) diameter. A control site of similar aerial extent and water depth and velocity was raked over to dislodge any organisms that may have been present. Seven weeks later, on June 5, 1979, five benthic samples were taken from each area with a modified Surber sampler, employing sailcloth side curtain extensions and 363-micron mesh netting. Additional samples were collected in the same manner on August 6, 1979, and September 11, 1979. All samples were preserved in a 10 percent formalin solution until organisms could be identified. Biomass of individual taxa was measured by volume displacement. The Jaccard coefficient of similarity was used to compare species distribution between the two sampling areas (Allen and Knight 1974).

RESULTS AND DISCUSSION

Population estimates were least accurate during the early sampling period, but improved to tolerable limits (within 30% $\pm$ at 90% C.I.) during the latter sampling periods (Table 1). This was likely due to highly clumped distributions from limited food sources (detritus) resulting in poor utilization of available habitat during the early colonization of the study areas, with increased organism dispersion later in the study period due to competition and more uniform food sources (periphyton) throughout the habitat.

TABLE 1
ACCURACY (% Deviation) IN DESCRIBING THE MEAN
(90% C.I.) FOR SAMPLES COLLECTED FROM THE TRINITY RIVER

Sample date:	June 5, 1979	August 6, 1979	September 11, 1979
small gravels:	44.6	23.2	30.2
large gravels:	53.8	28.6	27.2

Average numbers and biomasses of species of organisms collected from the area of a Surber sampler (0.0929 m^2) are shown in Tables 2 and 3 for the larger and smaller gravels, respectively. Nearly three times as many organisms were collected in the June and August samples and over twice as many in the September samples in the larger gravels as compared to the smaller gravels (Figure 1). The biomass of organisms was twice as much in the larger gravels for the June and September periods, and two and one-half times as much for the August period. The differences for total numbers and biomass between the larger and smaller graveled sampling areas are statistically significant at the 5 percent level.

The dominant organisms at both study areas included the mayflies Iron and Baetis, the caddisfly Hydropsyche, and the dipterans Simulium and members of the Chironominae. Iron, Simulium, and the Chironominae exhibited declines in population during the progression of the study, which is probably due to fall emergence of these organisms. Baetis populations showed a decline during the middle of summer, probably due to emergence, and an increase toward the end of summer, which is likely due to progeny of the spring hatch becoming large enough to capture in

Colonization trends of benthic organisms in
larger and smaller gravels in the Trinity River.

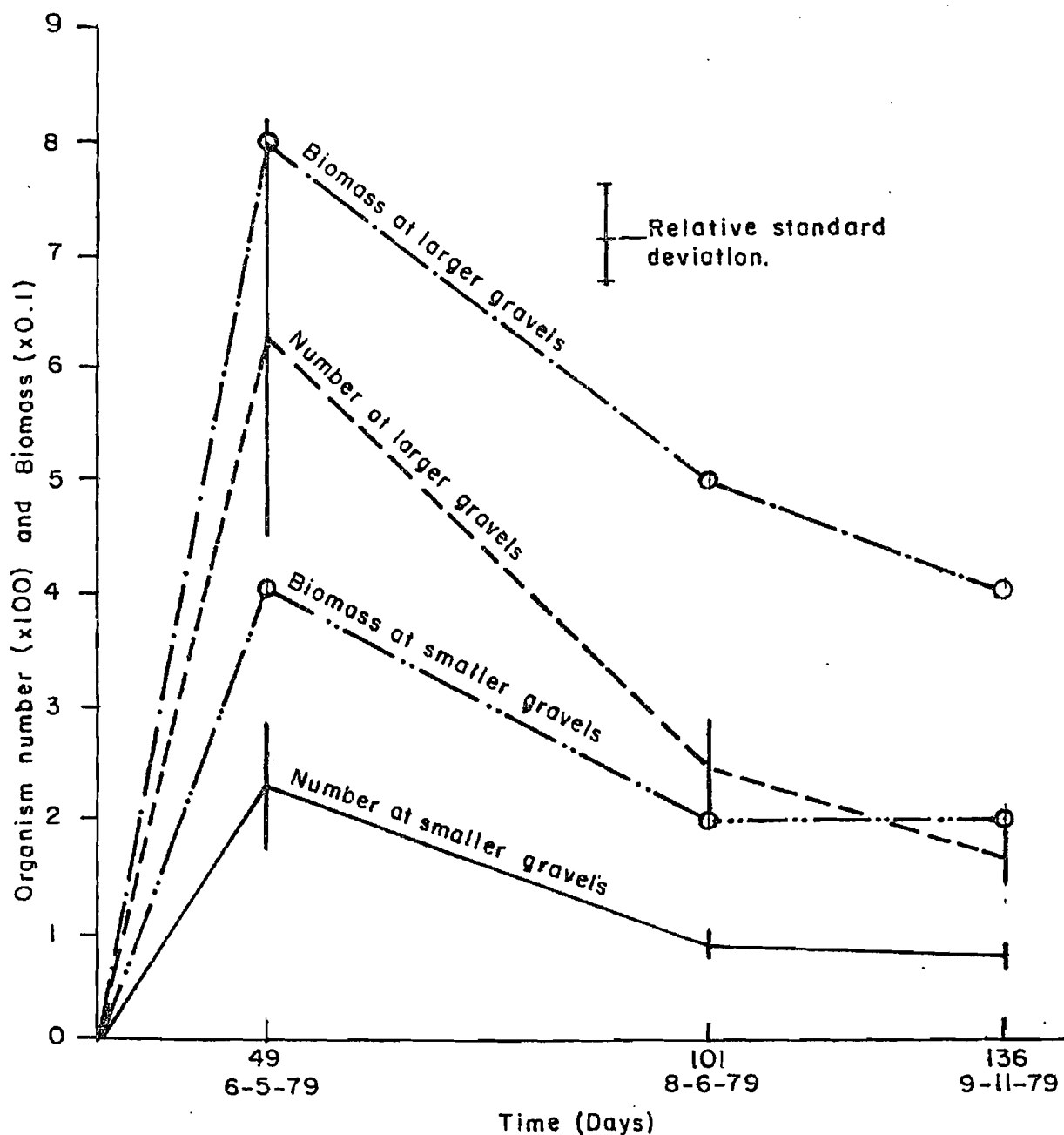


TABLE 2
AVERAGE NUMBER AND VOLUME
OF BENTHIC ORGANISMS FROM A SURBER SAMPLER
(0.0929 m²) FROM SMALLER GRAVELS ON THE TRINITY RIVER

	6/5/79		8/6/79		9/11/79	
	No.	Vol. (ml)	No.	Vol. (ml)	No.	Vol. (ml)
Ephemeroptera						
Iron	42.6	0.1	7.3	<0.1	7.0	<0.1
Rhithrogena					0.2	<0.1
Baetis	87.6	0.1	17.7	<0.1	24.6	<0.1
Ephemerella levis	0.2	<0.1				
E. heterocaudata	1.2	<0.1				
E. micheneri	2.8	<0.1	0.3	<0.1		
E. proserpina					0.4	<0.1
Paraleptophlebia			0.7	<0.1		
Plecoptera						
Isoperla bilineata	0.8	<0.1	3.0	<0.1	1.2	<0.1
Hastaperla						
Amphinemura					2.6	<0.1
Coleoptera						
Brychius					0.2	<0.1
Trichoptera						
Hydropsyche	0.6	<0.1	3.7	<0.1	13.4	<0.1
Hydroptila					5.0	<0.1
Rhyacophila					0.6	<0.1
Brachycentrus americanus	0.8	<0.1	1.0	<0.1	0.8	<0.1
Amiocentrus						
Lepidostoma					1.4	<0.1
Diptera						
Chironominae	38.2	<0.1	23.0	<0.1	14.2	<0.1
Calopsectra	0.4	<0.1			2.6	<0.1
Simulium	57.6	0.1	24.7	<0.1	0.4	<0.1
Antocha			3.0	<0.1	2.0	<0.1
Atherix					0.8	<0.1
Muscidae					0.2	<0.1
Mollusca						
Gyraulus deflectus	0.6	<0.1	1.7	<0.1	0.4	<0.1
Annelida						
Lumbriculidae						
Dina					0.8	<0.1
Platyhelminthes						
Dugesia	0.4	<0.1	2.0	<0.1	2.6	<0.1
Arachnida						
Hydracarina			1.4	<0.1		
Number of Organisms (N)	233.8		89.5		81.4	
Biomass (ml) of Organisms	0.4		0.2		0.2	
Number of Taxa	13		13		21	

TABLE 3
AVERAGE NUMBER AND VOLUME
OF BENTHIC ORGANISMS FROM A SURBER SAMPLER
(0.0929 m²) FROM LARGER GRAVELS ON THE TRINITY RIVER

	6/5/79		8/6/79		9/11/79	
	No.	Vol. (ml)	No.	Vol. (ml)	No.	Vol. (ml)
Ephemeroptera						
Iron	50.4	0.1	18.0	<0.1	11.2	<0.1
Rhithrogena					2.2	<0.1
Baetis	106.0	0.2	48.2	0.1	48.0	0.1
Ephemerella levis	0.2	<0.1				
E. heterocaudata	1.0	<0.1				
E. micheneri	1.4	<0.1			0.2	<0.1
E. proserpina						
Paraleptophlebia			1.0	<0.1		
Plecoptera						
Isoperla bilineata	1.2	<0.1	1.6	<0.1	1.4	<0.1
Nastaperla			0.2	<0.1		
Amphinemura			0.6	<0.1	5.6	<0.1
Coleoptera						
Brychius						
Trichoptera						
Hydropsyche	0.8	<0.1	40.0	0.2	38.4	0.2
Hydroptila			7.6	<0.1	6.4	<0.1
Rhyacophila			2.2	<0.1	1.0	<0.1
Brachycentrus americanus	0.6	<0.1	3.6	<0.1	1.4	<0.1
Amiocentrus	0.2	<0.1	0.4	<0.1	0.2	<0.1
Lepidostoma			1.0	<0.1	2.0	<0.1
Diptera						
Chironominae	61.4	<0.1	44.2	<0.1	37.2	<0.1
Calopsectra			7.8	<0.1	6.4	<0.1
Simulium	412.0	0.4	61.8	<0.1	1.0	<0.1
Antocha	0.2	<0.1	1.8	<0.1	1.0	<0.1
Atherix			2.2	<0.1		
Muscidae						
Mollusca						
Gyraulus deflectus			1.4	<0.1	2.0	<0.1
Annelida						
Lumbriculidae	1.0	<0.1				
Dina	0.2	<0.1	0.8	<0.1	4.2	<0.1
Platyhelminthes						
Dugesia	0.6	<0.1	10.6	<0.1	4.2	<0.1
Arachnida						
Hydracarina						
Number of Organisms (N)	637.2		255.0		174.0	
Biomass (ml) of Organisms	0.8		0.5		0.4	
Number of Taxa	15		20		19	

the samples. Hydropsyche generally increased in numbers as the summer progressed, probably due to growth and habitat selection by progeny of the spring hatch. Other organisms commonly collected from both sampling areas included the stonefly Isoperla bilineata, the caddisfly Brachycentrus americanus, the mollusc Gyraulus deflectus, and the flatworm Dugesia. Organisms collected only from the smaller gravels include the mayfly Ephemerella proserpina, the beetle Brychius, a dipteran of the Muscidae family, and the water mite (order Hydracarina). Organisms collected only from the larger gravels include the stonefly Hastaperla, the caddisfly Amiocentrus, and members of the annelid family Lumbriculidae. Populations of all of the common and most of the less common organisms were more abundant in the larger gravels than in the smaller gravels. Only a few rare organisms (Hydracarina, Ephemerella heterocaudata, E. micheneri, E. proserpina, Brychius, Antocha, and Muscidae) were more common in the smaller gravels.

The less common species tended to have specific habitat preferences, resulting in significant species differences between the two study areas. This was most prevalent in the June and August samples (Jaccard coefficient = 0.65 and 0.52, respectively). By September, though, there was greater overlap of species between the two areas (J.C. = 0.77).

Changes in species composition were significant from the June to August sampling periods in both the larger and smaller gravel areas (J.C. = 0.42 and 0.63 respectively). From August to September, significant changes in the species composition were still occurring in the smaller gravels (J.C. = 0.42), but only moderate changes were occurring in the larger gravels (J.C. = 0.76). This indicates that the macroinvertebrate community in the larger gravels are more stable and not as subject to radical changes in species composition.

CONCLUSION

Abundance and types of aquatic macroinvertebrates present is largely dependent on the nature of the substrate. Complex substrates generally contain the greatest diversity (variety) and abundance of aquatic organisms (Hynes 1970, Allan 1975). Substrates become more complex as the maximum size of the largest stones in a mixture of substrate sizes increases, which leads to greater habitat diversity (Hynes 1970, Reice 1974). Ecosystems exhibiting lack of species diversity may be unstable (Cairns 1974).

The size distribution of the gravels presently being used for riffle restoration in the Trinity River does not form very complex substrates. Habitat diversity is greatly reduced, which results in relatively low abundance and diversity of aquatic organisms. Such a system is unstable, with minor fluctuations in any component of the ecosystem resulting in radical changes in the biotic component. Such a system cannot provide an adequate or reliable source of food organisms for maximum fish consumption and survival.

It is recommended that future riffle restoration projects or modifications of existing projects incorporate buffer areas of complex substrate composed of gravel sizes up to those normally found in the Trinity River. Such substrates should favor diversification of the natural fauna of the Trinity River and provide important rearing areas for juvenile salmonids. Studies should be initiated to determine the optimum mixture of gravel sizes necessary to produce the most favorable habitat.

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