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Late-Winter Abundance and Substrate Associations of Benthos in Pool 13, Upper Mississippi River

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In Pool 13 on the Upper Mississippi River substantial differences were observed in macroinvertebrate abundance and substrate composition among six habitat types: tailwater, main channel, main channel border, side channel, slough, and lake. Densities were highest in slough, main channel border, and lake habitats, but the number of taxa was greatest in tailwater and main channel habitats. The abundance of 38 of the 42 identified taxa was significantly correlated with either the percentage of at least one particle size fraction or the percentage of organic matter in the substrate. Variation in substrate composition among the six habitat types appeared to influence macroinvertebrate abundance.

INDEX DESCRIPTORS: Mississippi River, Pool 13, macroinvertebrates, benthos, winter, substrate

The Upper Mississippi River between St. Louis, Missouri, and Minneapolis, Minnesota has a diverse array of aquatic habitats. Since the early nineteenth century man has sought to maintain or improve the navigation channel and to develop agriculture and industry in the watershed (Carlander, 1954). Navigation channel improvements culminated in the 1930's and 1940's with construction of 29 locks and dams. The dams raised water levels and created more area of perennial aquatic habitat, but also created sediment traps for the silt eroded from farmlands. Substrates within the Upper Mississippi River vary from fine silt in slow-moving backwaters to sand in channel areas, and to gravel in tailwaters and the main channel where the current is rapid. Today many backwater areas are being rapidly sedimented (Eckblad et al., 1977; Hesselberg, 1971). River managers are concerned about the effect of future changes on biological productivity — particularly on invertebrates.

Numerous assessments of benthic macroinvertebrates have been made in the Upper Mississippi River (Elstad, 1977; Helms, 1968; Simonet, 1978; Hall, 1980), particularly in slow-moving backwater habitats (Surber, 1954; Carlson, 1968; Gale, 1969, 1975; Davies, 1974; Eckblad et al., 1977; Trapp, 1979). Previous studies have not evaluated the macroinvertebrates in a variety of Upper Mississippi River habitat types to determine differences in abundance.

Influence of substrate composition on benthic macroinvertebrate abundance is well established (Cummins et al., 1964; Cummins and Lauff, 1969), although only a few studies have addressed the influence of substrate composition on benthos in the Upper Mississippi River (Carlson, 1968; Eckblad et al., 1977; Trapp, 1979; Hall, 1980). Most work has focused on species-specific interactions (Fremling, 1960; Carlander et al., 1967; Gale, 1971; Rogers, 1976). Winter abundance and diversity of benthic macroinvertebrates among Upper Mississippi River habitats is lacking. No published assessments are known to us.

The objectives of this study were to determine late-winter differences in benthic macroinvertebrate abundance among six habitat types of the Upper Mississippi River and to assess the influence of substrate composition on abundance. The findings may contribute to an understanding of the effects of habitat changes on the invertebrate productivity of the Upper Mississippi River.

STUDY AREA

The study was conducted on Pool 13, which extends from Mississippi River Mile (MRM) 521.4 near Fulton, Illinois, to MRM 555.5 at Bellevue, Iowa, a total of 55 km. Estimated surface area is 113.8 km^2 at normal water level.

Benthic invertebrates were assessed in the six habitat types as defined by Rasmussen (1979): (1) main channel — the portion of the river where large commercial vessels exclusively travel (minimally 2.7 m deep and 120 m wide); (2) main channel border — the region between the main channel and the river bank or islands, (contains a diversity of microhabitats many of which are the result of navigation channel development such as wingdams and revetments); (3) tailwaters — the river from dams extending downstream 1.6 km, including both the main channel and main channel border; (4) side channels — departures from the main channel and main channel border in which current is present during normal river stages; (5) lakes — isolated bodies of water on the floodplain that may be connected to the river, but have no current at normal river stages; and (6) sloughs — bodies of water connected to the main channel or main channel border having no current at normal river stages.

METHODS

Six sampling stations were established in each habitat type except side channel habitat, where eight stations were defined. All sampling stations were between MRM 527.0 and Lock and Dam 12 at MRM 555.5. Main channel border stations were sampled at sites with and without wingdams and at three distances from shore (10, 50, and 90 m). Three replicate samples were taken at each sampling station and each distance from shore within the main channel border stations. A total of 150 samples were collected in the survey.

Sampling was done from a boat with a Peterson dredge (0.092 m^2 sampling area) from February 26 to March 6, 1983. Dredge contents were preserved with formalin in glass jars. Water temperature and dissolved oxygen concentration were measured at each sampling station.

In the laboratory benthic samples were sifted through a 0.5 mm screen and all retained organisms were sorted, identified, and enumerated. Subsamples representing one-eighth to one-half of the sample were taken from samples exceeding 1 liter in volume. Gravimetric expansion was used to estimate total numbers of macroinvertebrates in each sample. The ratio of the air dried weight of the sample to that of the subsample was used as the expansion factor. Macroinvertebrates were identified to genus using the nomenclature of Pennak (1978). Exceptions to this procedure were unionid mussels (identified to species), dipterans (to family), oligochaetes (to class), and nematodes (to phylum).

Substrate

Particle size distribution of the substrate in the benthic samples was

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Table 1. Mean abundance (organisms/m^2; standard error in parentheses) of benthic macroinvertebrates in late-winter samples from Pool 13, Upper Mississippi River, February 26-March 6, 1983.

Taxa	Habitat Type					
	Tailwater	Main Channel	Main Channel Border	Side Channel	Slough	Lake
Hydrozoa	0	0	0	24.1 (24.1)	0	0
Tricladida	5.4 (2.9)	31.9 (31.8)	0.7 (0.7)	0	10.7 (10.7)	0
Nematoda	194.5 (101.9)	160.8 (83.0)	213.3 (56.5)	181.7 (76.0)	1913.0 (659.5)	455.8 (170.3)
Oligochaeta	105.4 (40.5)	1023.2 (350.3)	1796.9 (364.9)	1500.3 (392.3)	5234.3 (1122.3)	2006.3 (443.8)
Ostracoda	11.7 (9.4)	0	6.3 (5.0)	163.6 (133.4)	251.6 (105.1)	775.4 (336.5)
Isopoda						
Asellus	1.8 (1.0)	0	0	0	0	0
Amphipoda						
Hyalella	17.2 (10.6)	1.8 (1.8)	0	0	0	0
Gammarus	22.5 (21.9)	0	0	4.0 (4.0)	2.5 (2.5)	17.3 (17.3)
Hydracarina						
Limnesia	0	0	0	14.1 (10.4)	0	0
Plecoptera						
Isoperla	1.8 (1.8)	0.7 (0.7)	0	0	0	0
Perlesta	4.4 (4.4)	0	0	0	0	0
Ephemeroptera						
Stenonema	1.8 (1.3)	1.2 (0.9)	0	0	0	0
Hexagenia	2.4 (1.8)	0.7 (0.7)	141.5 (58.8)	231.1 (121.0)	402.2 (334.0)	65.7 (31.4)
Caenis	0.7 (0.7)	0	0	3.5 (3.5)	0	0
Unidentified Odonata	0	0.7 (0.7)	0	0	0	0
Other Odonata						
Chromagrion	1.2 (1.2)	0	0	0	13.4 (13.4)	5.7 (5.7)
Gomphidae	0	0.7 (0.7)	0	0	0	0
Hemiptera						
Corixidae	0.7 (0.7)	1.8 (1.8)	0	0	12.0 (12.0)	0
Megaloptera						
Sialis	0	0	0	0	7.8 (7.2)	0
Trichoptera						
Cheumatopsyche	60.8 (24.7)	55.8 (42.6)	4.6 (4.2)	0 0	7.2 (7.2)	0
Potamyia	179.0 (117.1)	36.1 (26.6)	4.9 (3.3)	0	7.2 (7.2)	0
Hydropsyche	3.6 (2.0)	12.0 (10.8)	0	0	0	0
Oecetis	0	0	1.0 (1.0)	0	0	6.9 (6.9)
Polycentropus	0.7 (0.7)	0	0	0	0	0

Table 1. (Continued)

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Taxa	Habitat Type					
	Tailwater	Main Channel	Main Channel Border	Side Channel	Slough	Lake
Orthotrichia	0	0	0	0	0	32.2 (32.2)
Lepidoptera						
Pyralidae	0	0	0	0	0	4.1 (4.1)
Coleoptera						
Stenelmis	1.2 (1.2)	2.4 (1.9)	1.0 (1.0)	2.0 (2.0)	0	0
Dubiraphia	0	0	1.0 (1.0)	0	0	0
Diptera						
Ceratopogonidae	14.3 (6.3)	7.8 (4.4)	89.5 (25.4)	591.2 (146.7)	644.2 (172.0)	841.4 (315.7)
Chironomidae	122.4 (32.6)	166.0 (58.2)	5000.0 (3583.2)	1023.5 (214.2)	766.2 (227.6)	2639.0 (1368.7)
Simuliidae	0	0	0.2 (0.2)	0	0	0
Chaoborinae	0	0	0	43.3 (22.7)	0	24.8 (13.7)
Gastropoda						
Viviparus	0.7 (0.7)	0	0	0	0	0
Lioplax	0	0.7 (0.7)	0	0	0	0
Gyraulus	0	0	0	0	10.8 (10.8)	0
Amnicola	0	6.6 (6.6)	0	0	0	0
Pelecypoda						
Sphaerium	23.0 (21.7)	53.5 (50.5)	0	43.0 (27.4)	52.1 (28.4)	295.2 (180.9)
Quadrula nodulata	0.7 (0.7)	0	0	0	0	0
Truncilla donociformis	1.2 (1.2)	0	0	0	0	0
Truncilla truncata	1.2 (1.2)	0	0	0	0	0
Leptodea fragilis	0	1.2 (0.9)	0	0	0	0
Obivaria reflexa	0	0	0.7 (0.7)	0	0	0

obtained by wet-sieving a core from the jar containing the sample through a series of six standard soil sieves with openings of different diameters (U.S. sieve number in parentheses): 2.0 mm diameter openings (10), 1.0 mm (18), 0.5 mm (35), 0.25 mm (60), 0.106 mm (140), 0.053 mm (270). The No. 10 sieve retained mostly gravel; the No. 270 sieve allowed silt and clay to pass through, but retained very fine sand. The other sieves retained fine to coarse sand particles (Cummins and Lauff 1969). The separated fractions were dried at 100°C and weighed to the nearest 0.01 g to estimate the relative abundance of each particle size. The organic content of the samples was estimated by measuring the loss of mass from core samples that had been placed in a furnace at 500-550°C for 30 minutes.

We conducted statistical analyses by using the Statistical Package for the Social Sciences (Nie et al, 1975). All decisions to reject null hypothesis were at the 95% probability level. Analyses included simple descriptive statistics, Pearson Product correlation (r), and one-way and two-way analyses of variance. We used a log $(x+1)$ transformation of abundance data to allow assumptions associated with the Pearson Product correlation to be more closely approximated.

RESULTS

The water temperature at the sampling stations ranged from 0.0 to 7.5°C during the sampling period. Water temperatures exceeded 4°C only on March 26, 1983, at slough sampling stations. Dissolved oxygen concentrations at all sampling stations were near saturation.

Forty-two taxa were identified from the survey (Table 1). The magnitude of variation in macroinvertebrate abundance among the habitat types was substantial. One-way analysis of variance indicated a statistically significant difference in abundance among the six habitat types for all the taxa identified. The greatest number of taxa were collected in tailwater (26) and main-channel habitats (20). From 13 to 15 taxa were identified from the other four habitat types.

Size distribution of particles in benthic samples varied among the six habitat types (Table 2). The percentage of organics in the substrate samples varied among the six habitat types. The concentration of organic matter was lowest (0.57%) in main-channel habitat; highest in slough and lake samples (6.8% each); and intermediate in main channel border (1.1%), tailwater (1.3%), and side channel (3.5%) habitats. The percentage of organics in substrate samples was highly correlated ($r = 0.75$, $p < 0.001$) with the percentage of fine silt and clay particles in the samples.

The abundance of 38 of 42 taxa found in Pool 13 samples was significantly correlated with the percentage of at least one particle size fraction or the percentage of organic matter in the substrate (Table 3). The only taxa to show no significant correlations with substrate composition were Pyralidae, *Stenelmis, Dubiraphia,* and *Obivaria reflexa*; however, these four taxa were rare in the benthic samples. Seventeen taxa had positive correlations with the gravel, six with medium-sized sand, and nine with silt and clay.

DISCUSSION

The composition of the late-winter benthos from main-channel border habitats of Pool 13 differed from that observed in the same pool during summer and autumn (Hall, 1980). Oligochaeta were the most numerous macroinvertebrates (51%) in Hall's study, and *Hexagenia* contributed the greatest biomass (64%). In addition to Oligochaeta, the most numerous organisms in Hall's samples were Ephemeroptera (21%), Diptera (18%), Trichoptera (8%), and Plecoptera (2%). Using Hall's taxonomic groups, we found Diptera (70%) to be most abundant in our late-winter main channel border samples, followed by Oligochaeta (25%), Nematoda (3%), Ephemeroptera (2%), and Trichoptera (1%). Hall collected 23 taxa during the summer and 27 in autumn, whereas we found 14 in late winter. Hall reported 476 to 903 organisms/m^2, whereas our mean was 7,261/m^2.

Density of late-winter benthos in Pool 13 also differed from summer samples in Pool 9. In a backwater, Big Lake, Eckblad et al. (1977) found *Sphaerium* (1,507/m^2), *Hexagenia* (730/m^2), Chironomidae (147/m^2), and Oligochaeta (130/m^2) to be the most numerous macroinvertebrates during summer, 1973 and 1974. The late-winter samples from lake areas of Pool 13 had *Sphaerium* (295/m^2), *Hexagenia* (66/m^2), Chironomidae (2,639/m^2), and Oligochaeta (2,006/m^2). *Sphaerium* and *Hexagenia* may have been less numerous in late winter because of the greater depth to which they may burrow during winter.

In selected backwater areas of Pool 8, Davies (1974) found up to 2,929 benthic organisms/m^2 with significant differences among seven sampling areas and all sampling dates. Davies' samples were dominated by Ephemeroptera (*Hexagenia*), Diptera, and Oligochaeta.

During summer in Pool 19, Carlson (1968) observed an average of 2,924 organisms/m^2 in lake habitat near Lock and Dam 19. Gale (1978) found a minimum of 8,000/m^2 at more upstream slough areas in Pool 19. Gale observed 22,000/m^2 in June and 58,000/m^2 in August 1967. Most of the organisms (80%) were *Sphaerium.* Samples from slough habitats of Pool 13 in late winter yielded an average of 9,338 organisms/m^2, of which *Sphaerium* composed only 0.6%.

Previous Upper Mississippi River studies found similar substrate associations for four of the most abundant taxa: Oligochaeta, *Hexagenia,* Chironomidae, and *Sphaerium.* Hall (1980) observed a positive correlation between the abundance of Oligochaeta, *Hexagenia,* and Chironomidae and the percent of silt-clay particles in the substrate; all three taxa were negatively correlated with percent sand. Trapp (1979) found summer abundance of Chironomidae and Oligochaeta in Lake Pepin positively correlated with percent clay, silt, and organics in the substrate and negatively correlated with sand. Sphaeriidae were also observed to be positively correlated with silt. Like Hall (1980) and Trapp (1979), we found positive correlations with the silt-clay fraction, but did not observe negative correlations with sand. Several studies have demonstrated *Hexagenia* and *Sphaerium* to be associated with soft muds (Carlander et al., 1967; Carlson, 1968; Gale, 1971, 1975; Rogers, 1976).

The late-winter study demonstrated substantial variation in abundance of benthos among different habitat types of the Upper Mississippi River. Macroinvertebrate density was greatest in habitats with large amounts of silt (slough and lake habitats), as well as in main channel border areas with extensive physical diversity. Macroinvertebrate abundance was lowest in areas having large substrate particles and high current velocities (tailwater and main channel habitats). Much of the variation in abundance and diversity appeared to be associated

Table 2. Mean particle size distribution as percent (standard error in parentheses) in benthic samples from Pool 13, Upper Mississippi River.

Particle size (mm)	Habitat and (in parentheses) number of samples					
	Tailwater (18)	Main Channel (18)	Main Channel Border (54)	Side Channel (24)	Slough (18)	Lake (18)
2	43.20	15.10	2.94	3.60	2.43	1.55
	(10.14)	(6.72)	(0.56)	(2.37)	(0.88)	(0.66)
1.1-2.0	1.40	7.10	6.19	2.97	1.07	0.91
	(0.34)	(2.32)	(0.92)	(0.78)	(0.29)	(0.31)
0.51-1.00	16.10	44.30	35.40	15.50	1.68	1.44
	(5.55)	(7.13)	(3.02)	(4.44)	(0.41)	(0.40)
0.26-0.50	30.60	27.70	35.90	19.40	2.00	3.09
	(7.31)	(5.49)	(2.66)	(5.22)	(0.42)	(0.81)
0.107-0.25	3.40	3.80	6.50	2.40	7.47	9.33
	(0.89)	(1.44)	(1.25)	(0.41)	(3.00)	(2.66)
0.054-0.106	0.79	0.26	1.11	2.67	11.10	6.68
	(0.34)	(0.10)	(0.26)	(0.95)	(3.99)	(3.28)
0.054	4.50	1.60	11.90	53.40	74.30	76.95
	(3.00)	(1.06)	(3.38)	(9.16)	(8.22)	(7.05)
Sample Size	18	18	54	24	18	18

Table 3. Statistically significant ($p < 0.05$) correlation coefficients of percent substrate composition versus macroinvertebrate abundance in benthic samples, Upper Mississippi River. Asterisk indicates log (x + 1) transformation of abundance.

Taxa	Particle size (mm)							Organic
	2	1.1-2.0	0.51-1.00	0.26-0.50	0.107-0.25	0.054-0.106	<0.054	Matter (%)
Hydrozoa	0.175	—	—	—	—	—	—	—
Tricladida	0.438*	—	−0.163	—	—	—	—	—
Nematoda	−0.149*	−0.205*	−0.222*	−0.175	—	—	0.335*	0.261
Oligochaeta	−0.347*	—	—	—	—	—	0.178	0.147
Ostracoda	—	—	−0.372*	−0.331*	—	0.263*	0.386*	0.472*
Asellus	0.192	—	—	—	—	—	—	—
Hyallela	0.240*	—	—	—	—	—	—	—
Gammarus	—	—	—	0.133	—	—	—	—
Limnesia	—	—	—	—	—	—	0.188*	0.160*
Isoperla	0.345*	—	—	—	—	—	—	—
Perlesta	—	—	—	0.178	—	—	—	—
Stenonema	0.525*	—	—	—	—	—	—	—
Hexagenia	—	−0.228*	−0.360*	−0.336*	—	0.258*	0.452*	0.364*
Caenis	0.170	—	—	—	—	—	—	—
Unidentified Odonata	0.254	—	—	—	—	—	—	—
Chromagrion	—	—	—	0.161*	—	—	—	—
Gomphidae	—	—	—	0.161	—	—	—	—
Corixidae	—	—	—	—	0.359	0.375	—	—
Sialis	—	—	—	—	—	0.189	—	—
Cheumatopsyche	0.631*	—	—	—	—	—	−0.170*	—
Potamyia	0.584*	—	−0.179*	—	—	—	—	—
Hydropsyche	0.603*	—	−0.145*	—	—	—	−0.139*	—
Oecetis	—	—	—	—	0.163	0.469	—	—
Polycentropus	0.308	—	—	—	—	—	—	—
Orthotrichia	—	—	—	—	—	—	—	0.170
Ceratopogonidae	−01.98*	−03.44*	−0.429*	−0.378*	—	0.197*	0.610*	0.556*
Chironomidae	−01.99	—	—	0.199	—	—	0.209*	0.201*
Simuliidae	—	—	—	—	—	—	—	—
Chaoborinae	—	—	−0.169	−0.183	—	—	0.285*	0.350*
Viviparus	0.243	—	—	—	—	—	—	—
Lioplax	—	—	—	0.161	—	—	—	—
Gyraulus	—	—	—	—	—	—	—	0.157
Amnicola	—	—	—	0.161	—	—	—	—
Sphaerium	—	−01.84*	−0.267*	−0.164*	0.162	−0.168*	0.274*	0.177*
Quadrula nodulata	0.243	—	—	—	—	—	—	—
Truncilla donociformis	0.270	—	—	—	—	—	—	—
Truncilla truncata	0.270	—	—	—	—	—	—	—
Leptodea fragilis	0.156	—	—	—	—	—	—	—

with substrate composition, with 38 of 42 taxa having statistically significant correlations between abundance and at least one component of the substrate.

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