Michael Hubbard

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# BOTTOM FAUNA OF A SEGMENT OF POOL 19, MISSISSIPPI RIVER, NEAR FORT MADISON, IOWA, 1967-1968[1]

*William F. Gale*[2]

ABSTRACT: This study was begun in 1966 as the first of a two-phase investigation to determine effects of dredging on fauna of Pool 19 of the Mississippi River. Monthly, from June to December 1967, four 7.6-cm core samples were taken at seven stations near the site of proposed dredging.

The molluscan fauna included 13 species of gastropods, 7 species of sphaeriids, and 22 species of unionids. Qualitatively, unionids appear to have changed little since 1930 to 1931, but *Anadonta imbecillis* has replaced *Amblema plicata* as the most abundant species. More than 80% of the organisms collected were *Sphaerium transversum*, with a mean of about 40,000/m$^2$. *S. transversum* was absent only on bare rock or sandy shores subject to wave action. *Fontigens nickliniana* and *Somatogyrus isogonus* were abundant snails.

Of the insects *Hexagenia* spp., because of their size, are most important as fish and duck food. In June up to 1,600 *Hexagenia*/m$^2$ occurred in shallow water; in winter, densities were greatest in deep water. *Cryptochironomus* sp. and *Coelotanypus* sp. were the most common chironomids and *Oecetis* spp. were the most abundant caddisflies.

Amphipods, *Hyalella azteca*, were associated with vegetation in shallow water in summer but occurred throughout the study area in fall. Leeches, *Glossiphonia complanata, Helobdella stagnalis* and *Erpobdella punctata* were abundant with densities ranging up to 68,000/m$^2$ in areas with shelter. *Limnodrilus hoffmeisteri* was the most common oligochaete.

Standing crops of benthos ranged up to 11,000 kg/ha in summer, a high biomass compared to other areas. Changes in biomass generally reflected changes in the standing crop of *S. transversum*. Total organisms/m$^2$ were maximum in fall. Standing crops of invertebrates in coves were extremely low and appeared to have been suppressed by fish predation.

## INTRODUCTION

As a resting and feeding site for hundreds of thousands of migrating diving ducks, Pool 19 is "unexcelled" on the upper Mississippi (A. S. Hawkins in a mimeographed report to U.S. Bureau of Sport Fisheries and Wildlife, May 5, 1966). Pool 19 ranked third among the 24 pools on the Upper Mississippi in commercial harvest of fish from 1953 to 1964 (Nord, 1967). The area is an important recreation center, providing excellent waterfowl hunting and sport fishing.

Plans of the U.S. Army Corps of Engineers called for dredging of a 2.6-km navigation channel below Fort Madison, Iowa (Fig. 1). In response, a cooperative study was initiated at Iowa State University in 1966 to investigate effects of dredging on bottom fauna, fish, and waterfowl.

The objectives of this study were to (1) survey bottom fauna in Pool 19 before dredging as a basis of comparison for post-dredging studies, (2) measure seasonal changes in bottom-

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[2] Ichthyological Associates, R. R. #1, Berwick, Pa. 18603.

fauna populations, and (3) gain information on life histories of some aquatic organisms. Only the first two objectives are reported here.

## Description of the Study Area

Pool 19 is a 75-km stretch of Mississippi River in extreme southeastern Iowa. The 13,560-ha pool (Nord, 1967) lies between dams at Burlington and Keokuk, Iowa. Extensive siltation has occurred since the river was dammed at Keokuk in 1913, and much of the area below Fort Madison (Fig. 1) is now less than 2 m deep.

Pool 19 is best described as a river-lake. Currents are substantial near the channel, but elsewhere are moderate to lacking. Daily mean water levels fluctuate only a few centimeters, except during spring flooding. Between Fort Madison and Montrose the pool is up to 4 km wide and wind-swept. Wave action roiled the substrate and kept secchi disk readings between 15 and 51 cm in July and August, 1966. Readings in quiet backwaters often exceeded 61 cm. Much of the area is less than 1 m deep; numerous backwaters are filled with American lotus, *Nelumbo lutea;* arrowhead, *Sagittaria* spp.; coontail, *Ceratophyllum* sp; and pondweeds, *Potamogeton* spp. In Summer, sloughs are blanketed with duckweed, *Lemna* spp.; watermeal, *Wolffia* sp.; and mosquito fern, *Azolla* sp.

## Description of Stations

In 1966 nine transects were sampled between river miles 374 and 385 (Fig. 1). Most data reported here came from systematic sampling in 1967 in the vicinity of proposed dredging; primarily on Transect 3. Transect 3 was selected because it (1) bisected the proposed dredging site, (2) contained a variety of habitats, and (3) was readily accessible from a docking facility.

Station 1 (Table 1) located in the center of a backwater area, lacked measurable current and was adjacent to submergent and emergent vegetation. A greater variety of benthic organisms was found at Station 1 than at other stations.

Stations 4 to 8 on Transect 3 were about 260 m apart on a broad, level area called the "flats." Stations 4 to 7 were shallow and contained substantial amounts of sand (Fig. 2). Stations 5 and 6 had swiftest currents and sandiest substrates. Station 8, at the junction of the "flats" and the channel. was subject to deposition of detritus including piles of empty sphaeriid shells up to 8 cm deep.

Three stations with clayey silt substrates were selected according to depth and location on the Illinois side of the channel. Station 9, near the channel, was downstream from an island and shallow. Station 10, in an old channel, was deep. Station 14 on Transect 4 was selected because it was shallow, close to shore, and not adjacent to vegetation.

Stations 2 and 3 on Transects 5 and 8 lacked measurable currents and were adjacent to submergent and emergent vegetation. They were representative of cove areas and were sampled in 1967 to reaffirm findings of 1966 that such areas contain low standing crops of benthos.

# PROCEDURES

## Method of Sediment Analysis

Substrates analyzed for particle size distribution were collected with a frozen core sampler (Shapiro, 1958). Because most organisms were thought to occur in the upper 4 cm of substrata, only that portion of the core was used in particle-size analysis. To obtain sufficient substrate for analysis, upper strata from four to five cores were combined. Sediments were analyzed by the Bouyoucos hydrometer method as described by Dawson (1959).

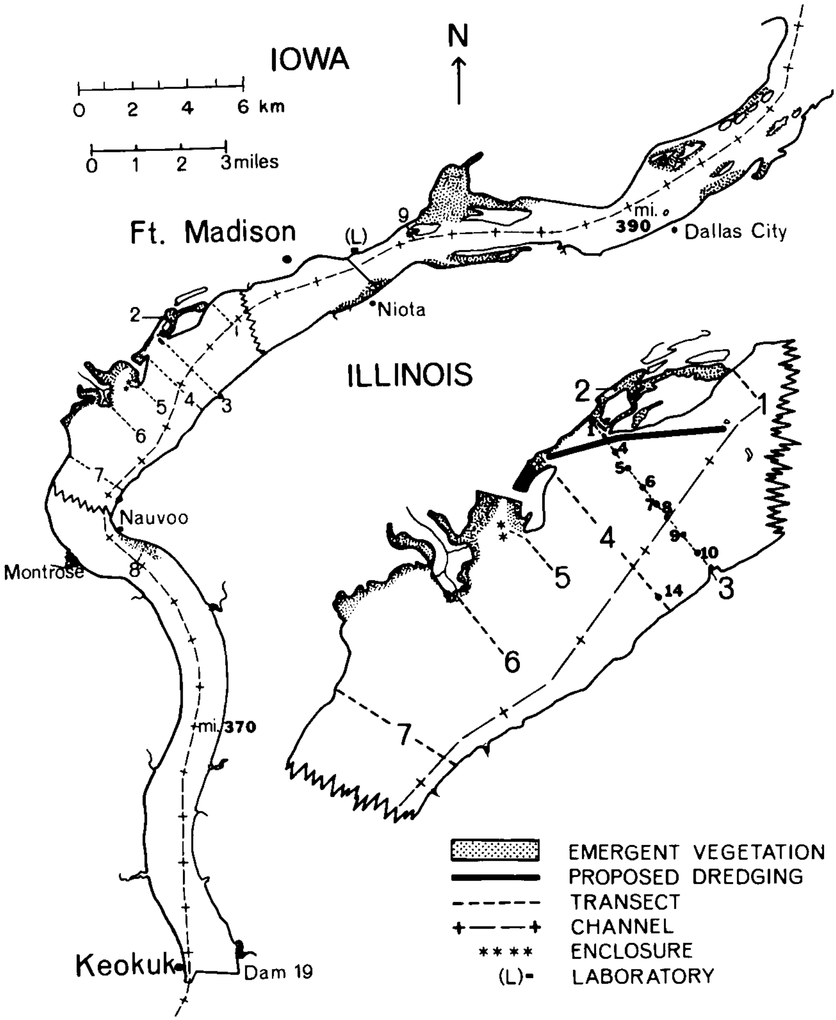


Figure 1. Pool 19 of the Mississippi River, showing 1966-68 sampling transects.

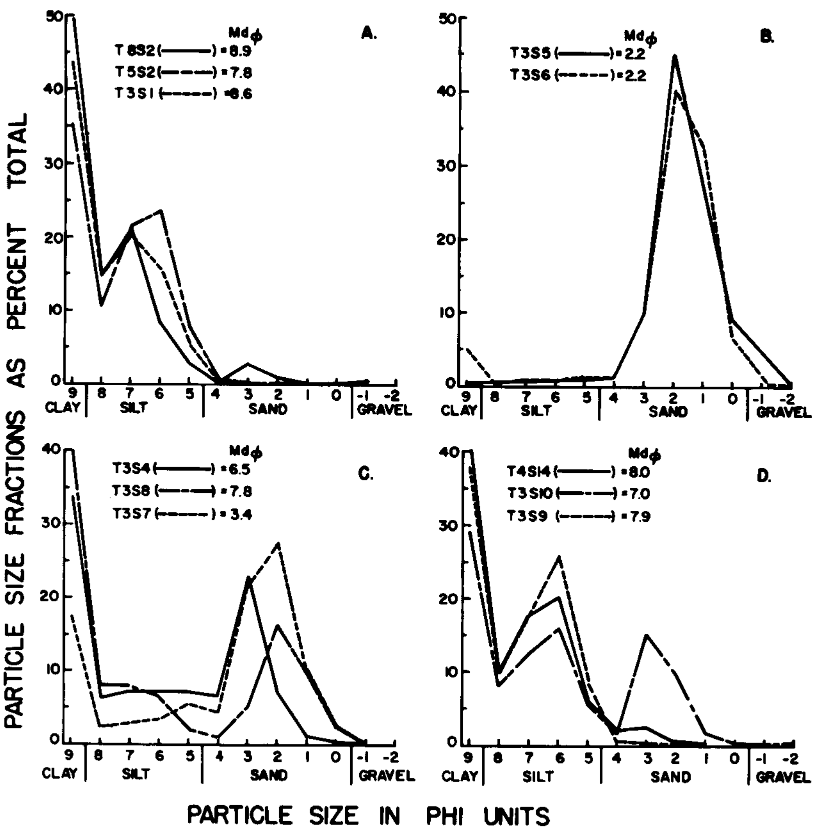


Figure 2. Particle-size fractions of substrates of 11 stations in Pool 19, Mississippi River, classified as A—clayey silt, B—sand, C—clay sand, and D—clayey silt.

Table 1. Description of sampling stations in 1967

| Transect | Station | Depth (m) | Substrate[a] type | Velocity[b] (m/sec) | Adjacent[c] vegetation | Meters to shore Iowa | Meters to shore Ill. | River mile[d] (approx.) |
|---|---|---|---|---|---|---|---|---|
| 3 | 1 | 0.66 | clayey silt | none | yes | 77 | - | 379.4 |
| 3 | 4 | 1.22 | clay-sand | .098 | no | 415 | - | " |
| 3 | 5 | 1.22 | sand | .118 | no | 686 | - | " |
| 3 | 6 | 1.27 | sand | .145 | no | 957 | - | " |
| 3 | 7 | 1.75 | clayey sand | .127 | no | 1222 | - | " |
| 3 | 8 | 2.62 | clay-sand | .095 | no | 1463 | - | " |
| 3 | 9 | 1.24 | clayey silt | .051 | no | - | 674 | " |
| 3 | 10 | 3.15 | clayey silt | .094 | no | - | 286 | " |
| 4 | 14 | 0.84 | clayey silt | .046 | no | - | 61 | 378.9 |
| 5 | 2 | 0.53 | clayey silt | none | yes | 686 | - | 378.3 |
| 5 | 3 | 0.39 | clayey silt | none | yes | 838 | - | 378.3 |
| 8 | 2 | 0.53 | clay-silt | none | yes | - | 457 | 374.2 |
| 8 | 3 | 0.76 | clay-silt | none | yes | - | 610 | 374.2 |

[a]Designated according to predominant particle types (Fig. 2).
[b]Measured with a pygmy Gurley current meter about 8 cm from substrate surface.
[c]Within 100 m of vegetation.
[d]Mile zero at junction of Mississippi and Ohio rivers.

## Sampling Methods for Benthos

In 1967, sampling began in late March by use of Peterson and Ekman grabs. Both grabs were unsatisfactory at some stations and a 7.6 cm core sampler (Gale, 1971a) was used in June and thereafter. Data obtained with grabs cannot be realistically compared with results of core sampling and are excluded here.

Monthly, from June to December, four core samples were taken at Stations 1, 4, 6, 7, 8, and 10 on Transect 3 and at Station 14 on Transect 4. Sampling at Stations 5 and 9 was terminated early when station markers were lost.

Samples were washed in a screening bucket (Fremling, 1961) with a screen containing about 12 mesh per cm. Probably some insects in early instars and tiny oligochaetes, such as *Chaetogaster* sp., passed through the screen. Use of mesh fine enough to retain near-microscopic sized organisms would have greatly hampered sample washing and sorting, and far fewer samples could have been analyzed. Living organisms were graded into three size classes and placed into separate plastic bags partially filled with river water. Sphaeridds, if not killed immediately, discharge young into the sample, biasing the count upward. By field grading, mature clams were isolated; later the young discharged in bags with mature clams were not counted. Samples were refrigerated in the bags to increase survival time for the organisms. Sorting samples with living organisms facilitated finding inconspicuous forms and made recognition of living snails easier. Samples collected from October to December were preserved in 10% buffered formalin at the collection site. Alcohol was an unsuitable preservative for sphaeriids because it permitted the valves to open after a few weeks and the soft parts to float out.

Acrylic tubes, with sections of brass welding rods spaced across the bottom, were used to sort clams into six size groups based on width: <1 mm, 1 to 2, 2 to 3, 3 to 4, 4 to 5, and >5 mm. Average clam weights (to nearest milligram) were obtained for a random sample of each size group. Weights included blotted dry with shell intact, blotted dry without shell, and oven dried (100°C for 12 hours) with shell removed. The weights (Gale, 1969, p. 21) were used to convert numbers of clams in samples to weights. Estimating clam weights saved considerable time and eliminated errors caused by leakage of mantle fluids from clams with broken shells.

Blotted dry weights for unbroken clams were obtained by spreading the clams on paper toweling on one side and then the other. Clams were then allowed to air dry (1 to 5 minutes) until the entire periostracum became dry. To quantify weight loss due to evaporation (after the periostracum dried), 7.274 g of sphaeriids of various sizes were weighed each minute for 10 minutes. Weight loss was gradual and only 0.7%.

After the shells were dissolved with 5% HCL, clams were blotted on toweling to remove excess moisture. Weights were taken after visible water films disappeared. Attempting to standardize blotting time was impractical since small and large clams dried at different rates. Blotted dry weights for other organisms were obtained in the same way. Except that larger unionids were weighed to the nearest 0.01 g, and non-molluscan groups were weighed and read to the nearest 0.1 mg.

Because too few unionids were collected during systematic sampling to formulate a comprehensive species list, additional mussels were gathered by hand in shallow water and with a crowfoot dredge in deeper water.

Numbers of organisms per core sample were converted to numbers per square meter by multiplying by 219.28. Source materials used in identification of organisms are listed in appendix of Gale (1969). Names and addresses of authorities making identifications or providing verifications also are there.

## RESULTS AND DISCUSSION

### Standing Crop

Standing crops of benthos (excluding unionids) were generally greatest in July, August, or September (Fig. 3.) *S. transversum* were usually the major portion of the summer standing crop in numbers and weight (Figs. 3, 4). The greatest standing crop, nearly 11,000 kg/ha, occurred at Station 8 in August. At about the same time 9,000 kg/ha was found at Station 7. About 98% of the biomass was *S. transversum.*

Between June and August the biomass at Station 8 increased at a rate of 4,653 kg/ha per month. Although the change in biomass was not synonomous with production, it suggests high production.

Standing crops dropped sharply between August and September at Station 8, primarily because of reductions in sphaeriid numbers. At the same time, the standing crop of leeches increased markedly, suggesting a possible cause-and-effect relationship. Leech numbers were not great in October but by that time sphaeriids had almost disappeared. The rise in standing crop to nearly 5,000 kg/ha in November was primarily due to high leech density.

Data from Stations 10 and 14 were averaged because the stations were considered representative of clayey-silt areas lacking vegetation. From a peak in July, benthos biomass declined until October. The decline resulted from disappearance of larger sphaeriids at Station 14 and emergence of mayfly naiads, *Hexagenia* spp. Numbers of organisms (Fig. 4) continued to increase into August and September, due to increased numbers of small sphaeriids.

Station 1 was probably typical of the vegetated backwater portion of Transect 3, but was atypical of most shallow areas adjacent to vegetation because it received effluent from organically enriched Hoenig's slough. Stations 2 and 3 on Transect 5 and 8 appear more characteristic of shallow areas.

The standing crop at Station 1 deviated markedly from those at other stations. In July the standing crop (Fig. 3) fell as sphaeriid populations decreased, but in August, as more snails *(Valvata tricarinata* and *Amnicola lustrica)* moved to the substrate, the standing crop began to rise again. As aquatic plants disappear in fall, associated benthos, such as *Valvata* and *Amnicola,* moves to the substrate where it is vulnerable to sampling.

Data from Stations 4, 6 and 7 were averaged because they had similar substrates, currents and depths, and were close to one another. Station 8 was excluded from the group because of its greater depth, faster current, and more heterogeneous substrate (Table 1). At Stations 4, 6 and 7, changes in standing crop estimates usually followed trends in *S. transversum* (Fig. 3). After September, as larger clams disappeared and numbers of insect larvae increased, *S. transversum* composed a lower percentage of the total weight. Although biomass declined after September, numbers of organisms increased (Fig. 4).

In 1966 and 1967 the standing crop in cove areas adjacent to vegetation (Stations 2 and 3 on Transects 5 and 8) was extremely low, averaging less than 2,000 organisms/m$^2$. At Station 14, where substrate, particle-size distribution was almost identical to that of Stations 2 and 3 (Fig. 2), the standing crop was much greater; in June it was 22,000/m$^2$ and in August, 1967, it was 58,000/m$^2$. Most of the organisms were *S. transversum.* In laboratory substrate preference experiments (Gale, 1971b) *S. transversum* preferred mud to sand and sandy-mud. Yet in the river some areas with mud, such as Stations 2 and 3, contained few clams and some other areas with less desirable substrate, such as Stations 4, 6 and 7, contained many clams. Particle size may be of great importance in determining the distribution of *S. transversum,* but clearly there can be overriding factors. Fish may be one such factor.

Populations of carp *(Cyprinus carpio)* and some other fish were extremely abundant in coves and may have controlled expansion of invertebrate populations by continual predation. Sphaeriid populations in enclosures (excluding fish at Station 2, Transect 5) were about four times greater than in a control enclosure (Gale, 1973). Invertebrate populations in hundreds of hectares of Pool 19 may be suppressed by fish predation, but the effect fish predation has on benthos production is less clear.

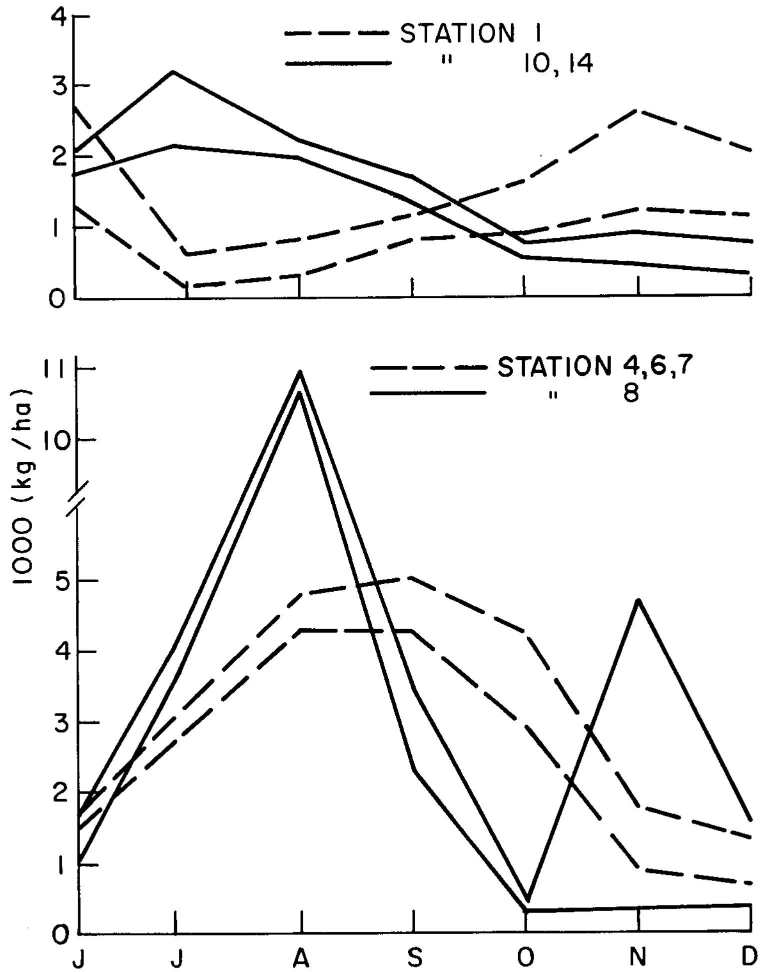


Figure 3. Standing crop of benthos in four habitats in Pool 19, Mississippi River, 1967. The lower line of each pair represents the standing crop of *Sphaerium transversum*. Mollusc weights are exclusive of shells and all weights are blotted weights.

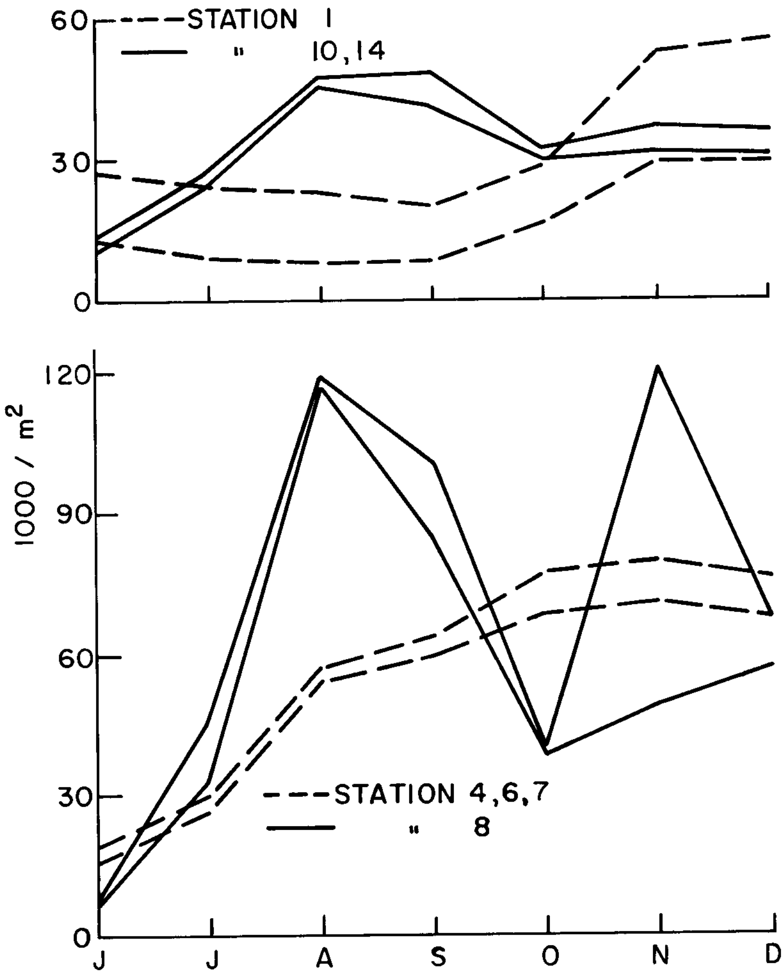


Figure 4. Numbers of benthic organisms in four habitats in Pool 19, Mississippi River, 1967. The lower line of each pair represents the standing crop of *Sphaerium transversum*.

Generally, the standing crop at the nine stations systematically sampled in 1967 was greater than that reported in other studies. Hayes (1957) reviewed standing crop data from 251 lakes and found that most contained less than 100 kg of benthos/ha. Moyle (1961) found that most ponds, lakes, and rivers contained less than 560 kg/ha of benthos. Two areas, the Mississippi River and slow streams in New York, were reported to have at some times standing crops exceeding 1,000 kg/ha, with a maximum of 3,982 kg/ha. Richardson (1921) reported up to 5,807 kg/ha of benthos in the Illinois River prior to heavy pollution loads. Most of his estimates, however, were less than 500 kg/ha. Zhadin and Gerd (1963) reported standing crops sometimes exceeding 10,000 kg/ha in the Don River, but mollusc shells may have been included in the total. Very low standing crops of benthos were reported for the Missouri River. Berner (1951) and Morris et al. (1968) reported less than 1 kg/ha and Grover (1969) reported 11.3 kg/ha in an impounded stretch.

Carlson (1968) reported 2,024 organisms/m$^2$ in the lower portions of Pool 19 in 1960-61. The lowest number of benthic organisms found upriver during systematic sampling in 1967 (Fig. 4) exceeded 8,000/m$^2$. During September, 1967, random sampling of the lower portion of Pool 19 (from Nauvoo, Illinois to Keokuk, Iowa) with a ponar grab (Gale, 1969) produced 14,656 sphaeriids/m$^2$ (506 kg/ha—damp weight without shells and mantle fluids). Thornburg (1973) collected 112 ponar samples in Pool 19 in November, 1969, and found an average of about 1,800 kg (including shells) of sphaeriids/ha between Nauvoo and Keokuk. Depending upon clam size, from 45 to 54% of *S. transversum's* weight is shell and mantle fluids (Gale, 1969, p. 35). The Ekman grab used by Carlson (1968) probably did not penetrate deep enough (up to 17 cm) to obtain all sphaeriids. Also, Carlson formulated a volumetric index for estimating sphaeriid numbers to reduce counting time. An index formulated when many large sphaeriids were present (June and July) would greatly underestimate the population when larger clams disappear (August and September). These sampling differences probably do not account for all the differences between 1960-61 and 1967 estimates.

## Taxa

### *Oligochaeta*

Large numbers of oligochaetes *(Chaetogaster limnaei)* were found inhabiting the mantle cavities of *S. transversum* in Pool 19 (Gale, 1973). *Chaetogaster* was too small for retention by the screening bucket and may have been abundant on the substrate also. Larger oligochaetes were most abundant in dark clayey silts of Stations 1 and 9 (Table 2). Station 9 was downstream from a small island heavily used for "loafing" by migratory waterfowl, and the oligochaete population may have been enhanced by duck feces. Station 9 with its fast current and sandy substrate contained fewest oligochaetes. Of the large oligochaetes, *Limnodrilus hoffmeisteri* was the predominant species at all stations.

Table 2. Numbers of oligochaetes/m$^2$ at nine stations in Pool 19 of the Mississippi River from June through December, 1967. (Stations 9 and 5 were sampled from June through September and October, respectively.)

| Station | Number/m$^2$ | |
|---|---|---|
| | Range | Mean |
| 1 | 6,284 - 16,278 | 11,752 |
| 4 | 155 - 4,216 | 2,204 |
| 5 | 979 - 1,834 | 1,289 |
| 6 | 334 - 1,732 | 987 |
| 7 | 2,655 - 10,644 | 6,185 |
| 8 | 427 - 10,010 | 3,374 |
| 9 | 18,870 - 33,424 | 23,497 |
| 10 | 393 - 4,124 | 1,829 |
| 14 | 599 - 4,873 | 2,101 |

Oligochaetes were too fragmented in screening to be counted and numbers were estimated by dividing total oligochaete weight in samples by calculated mean weights. Mean weights were determined by dividing the weight of worms by the number of prostomiums in six subsamples.

*Hirudinea*

Leeches found from 1966 to 1968 were as follows:

Glossiphoniidae

*Helobdella fusca*, *H. nepheloidea*, *H. stagnalis*, *Glossiphonia complanata*, *Placobdella montifera*, *P. parasitica*

Erpobdellidae

*Erpobdella punctata*, *Illinobdella* sp., Unidentified

Leeches were abundant in Pool 19 and almost every empty mussel shell or piece of wood contained one or more. They were much more abundant in 1967 than in 1960-61 (as reported by Carlson, 1968). *G. complanata*, *H. stagnalis*, and *E. punctata* were most abundant. Leech numbers increased in late summer and early fall (Fig. 5). The largest numbers of leeches occurred on sandy substrates.

Erpobdellids were most abundant at Stations 1, 9, 10, and 14, where the substrate was clayey silt. Erpobdellids often live in burrows in soft substrate; since they swim rather than creep, soft substrates do not hamper their locomotion. Firm substrates are probably important to glossiphoniids, which creep and require firm substrates for anchorage. At Stations 4 to 8, with firm substrates, 90% of the leeches were glossiphoniids. Concentrations of leeches at Station 8 may have been due to accumulations of empty sphaeriid shells, which glossiphoniids use as "cover". Between June and August 70% of the leeches were erpobdellids, but after August glossiphoniids became more abundant.

In Pool 19, leeches may compete with fish and ducks for food. Glossiphoniids, especially *G. complanata*, are voracious predators on sphaeriids (Gale, 1973). Insect larvae and other invertebrates may also be consumed. Leeches, however, are food for several species of fish and some ducks.

*Insecta*

The following mayflies were collected during 1966-67: *Stenonema* sp., Heptageniidae; *Hexagenia* spp., Ephemeridae; *Caenis* sp., Caenidae.

Large numbers of *H. limbata* and *H. bilineata* inhabit Pool 19 (Fremling, 1960). Carlander et al. (1967) estimated June populations of naiads in Pool 19 at 3.6, 18.7, 6.7, 23.6, and 11.9 billion in 1959 to 1963, respectively, and suggested an alternate-year cycle of abundance. Fremling (1959) observed that various age groups of *H. bilineata* were not evenly mixed. Some areas contained "mostly nymphs of one brood," whereas, adjacent areas contained "predominantly younger or older nymphs." Mixed size classes were common in the same Ekman sample in the present study and that of Carlson (1960).

In June *Hexagenia* were most abundant in shallow water, but in December greatest densities occurred in deeper water. The difference was particularly striking in December when some stations with rather sandy substrates in deep water contained more naiads than stations with clayey silt in shallow water. In laboratory experiments *Hexagenia* usually selected mud (clayey silt) when mud, sandy-mud, and sand were presented simultaneously.

In October, 1968, additional samples were collected near Station 14 to investigate further the relationship between water depth and *Hexagenia* density. The area was selected because of homogeneous substrates and gradual but fairly rapid increases in water depth. Station 14 contained high populations (up to 1,590/m$^2$) of *Hexagenia* in June 1967 and low densities in November and December. Mayfly density increased with water depth (Table 3). Greater mayfly density in deep water may have resulted from more eggs being deposited or drifting there to hatch, or young naiads may have migrated to deep water from shallow areas. Swanson (1967) found *Hexagenia* most abundant in shallow water after the summer hatch in Lewis and Clarke Reservoir in the Missouri River. Density remained greater in shallow water but many naiads migrated to deeper waters.

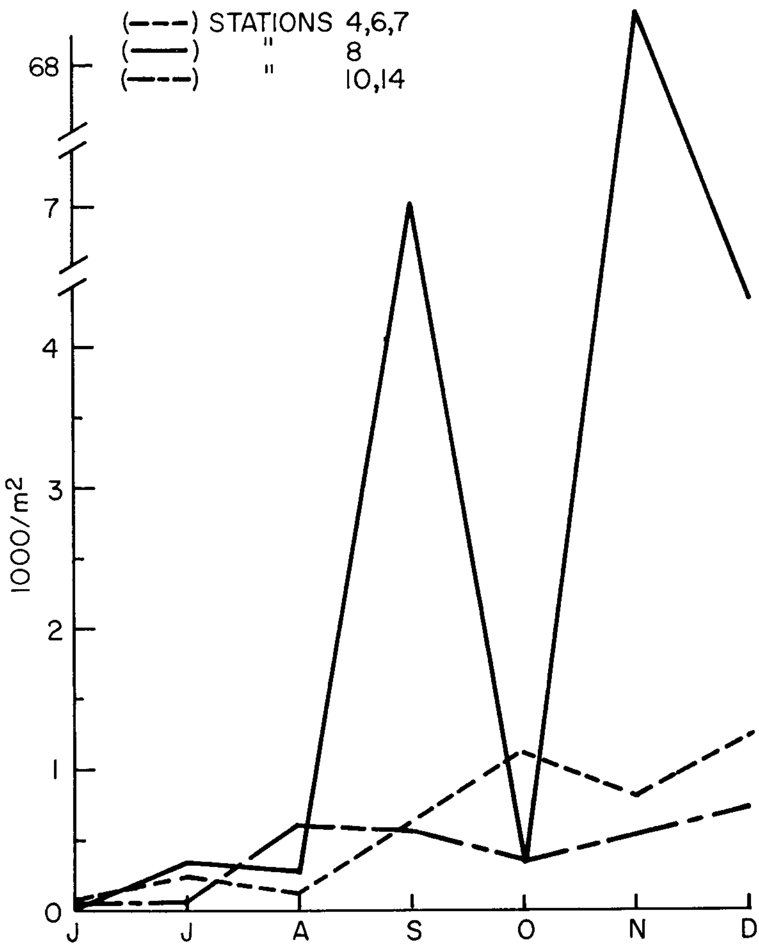


Figure 5. Numbers of leeches in three habitats in Pool 19, Mississippi River, 1967.

Few *Hexagenia* large enough to be retained by the screening bucket were present in August, after emergences in June and July; slightly more were collected in September. *Hexagenia* is probably the most important insect as fish food. Jude (1968) and Ranthum (1969) collectively listed 13 fish species that heavily utilized *Hexagenia*. The disappearance of *Hexagenia* in summer probably increases predation on sphaeriids and may contribute to the drop in sphaeriid biomass between August and September (Fig. 3). In fall and spring, *Hexagenia* are also eaten by diving ducks (Thompson, 1973).

Table 3. Numbers of *Hexagenia* at various depths near Station 14, Pool 19, Mississippi River, October, 1968.

| Depth (m) | *Hexagenia*/$m^2$ | Distance from Illinois shore (m) | Ekman grab samples |
|---|---|---|---|
| 0.8 | 323 | 10 | 2 |
| 1.0 | 754 | 75 | 2 |
| 2.7 | 1,636 | 125 | 2 |
| 4.3 | 2,390 | 200 | 4 |

*Caenis* sp., although not abundant, was widely distributed. *Stenonema* sp. was collected infrequently.

Caddisflies collected in 1967 were *Oecetis* spp., Leptoceridae; *Cheumatopsyche* spp., Hydropsychidae; unidentified species, Hydroptilidae.

*Cheumatopsyche* was especially abundant at Stations 7 and 8 in July (Fig. 6). Later, *Oecetis* generally was more abundant. Caddisflies are food for many fish species (Jude, 1968) and diving ducks (Thompson, 1973).

The following chironomids were collected in 1967:

Tanypodinae—*Ablabesmyia* sp., *Anatopynia* sp., *Clinotanypus* sp., *Coelotanypus* sp., *Procladius* sp., *Tanypus* sp.

Chironominae—*Chironomus* sp., *Cryptochironomus* sp., *Polypedilum* sp.

*Cryptochironomus* and *Coelotanypus* were widely distributed in Pool 19 and probably were the two most common species. Carlson (1963) reported *Stenochironomus* also to be abundant in Pool 19.

The population of chironomids large enough to be retained in the screening bucket was low from June through August but increased in September (Fig. 7) and remained high through December. Chironomids were important food items for fish (Jude, 1968) and diving ducks (Thompson, 1973), but because of their small size chironomids are probably less important as food than *Hexagenia*.

*Crustacea*

Amphipods, *Hyalella azteca*, were abundant in vegetated backwaters. Because *Hyalella* spends much of its time on plants, few were collected in substrate samples prior to October when *Hyalella* was collected in low numbers at most sampling stations. The disappearance of submergent plants in fall may have caused some amphipods to disperse but densities remained greater in shallow water where decaying vegetation provided shelter and perhaps food.

Aquatic isopods, *Asellus* sp., were found infrequently.

*Gastropoda*

The following gastropods were found during 1967-68. Species followed by an asterisk were not found during quantitative sampling:

Pulmonata
    Physidae—*Physa anatina, P. gyrina*
    Planorbidae—*Helisoma trivolvis**
    Ancylidae—*Laevapex fuscus**
Ctenobranchiata
    Amnicolidae—*Amnicola lustrica, A. sayana*, Fontigens nickliniana, Somatogyrus Somatogyrus isogonus*
    Viviparidae—*Campeloma crassula, Lioplax sulculosa, Viviparus georgianus*
    Valvatidae—*Valvata tricarinata*
    Pleuroceridae—*Pleurocera acuta*

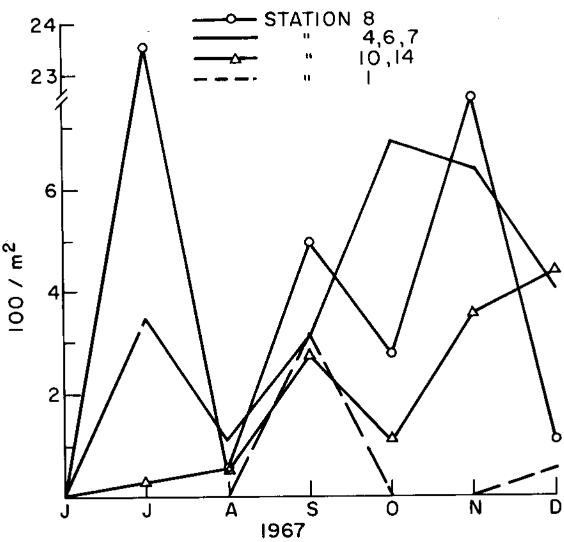


Figure 6. Numbers of caddisflies in four habitats in Pool 19, Mississippi River, 1967.

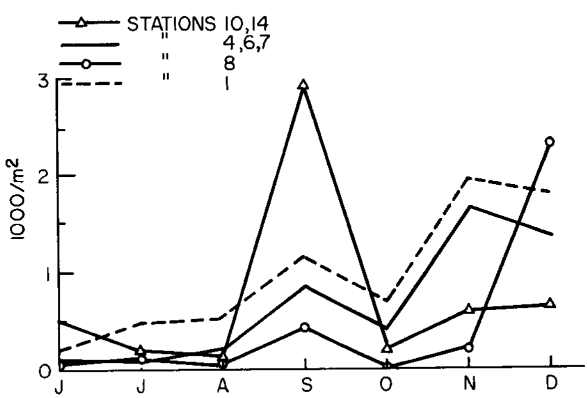


Figure 7. Numbers of chironomids in four habitats in Pool 19, Mississippi River, 1967.

Five snails *(F. nickliniana, V. tricarinata, P. acuta, A. lustrica,* and *S. isogonus)* were more abundant than the others (Table 4). *Fontigens,* one of the small snails, was the only one collected at all stations during systematic sampling. Additional sampling revealed that *C. crassula* and some others were present in low numbers at all stations. *Fontigens* was most abundant on the "sandy flats", reaching densities of 1,700/m$^2$ at Station 5. At Station 6, where the current was strongest and the substrate sandiest, *Fontigens* was not abundant and composed only 12% of the snail population. At Stations 5 and 7, *Fontigens* made up 65 and 50%, respectively, of the gastropods. *Fontigens* was most abundant in August, and least abundant in December, 1967.

*Pleurocera acuta,* with its heavy cone-shaped shell, was most numerous at Station 6 where it made up 49% of the snail population. *Somatogyrus* and *Lioplax* were also more abundant on the sandy flats. *Somatogyrus* was not collected at any of the nine stations during June and July, but probably was present in low numbers. In August *Somatogyrus* suddenly appeared at seven stations in substantial numbers and became one of the more abundant snails. Reproduction seems to have caused the increase. *Somatogyrus* collected in August were about 3 to 4 mm high but by September had grown to 7 to 8 mm high and increased in weight 6 to 7 fold. In August 1967, *Somatogyrus* populations at Stations 1, 4, 6, 7, 8, 10, and 14 averaged 156/m$^2$, then fell to 16/m$^2$ by December. *Somatogyrus* was important diving-duck food (Thompson, 1973); much of its decline was probably due to duck predation.

*Amnicola lustrica* and *Valvata tricarinata* were associated with submergent vegetation at Station 1, where they were more than 95% of the snail population. *A. lustrica* occurred throughout the sampling area, even where vegetation was lacking. *Valvata* was restricted to Station 1 where it made up over 70% of the snail population.

*Viviparus,* the largest snail in the area, was frequently observed but was not abundant. *Physa anatina* was associated with submergent vegetation in shallow water, whereas the much larger *P. gyrina* usually inhabited open water zones. *H. trivolvis* and *A. sayana* occurred at Station 1. *Laevapex fuscus* was found on vegetation at Transect 5.

Upon the basis of random ponar grab sampling in September, the snail population between Dallas City and Keokuk appeared similar, qualitatively, to that in vicinity of Transect 3. The major difference was that *Valvata* was not found in any of the ponar samples. Between Dallas City and Keokuk, *Somatogyrus, Lioplax, Campeloma,* and *Viviparus* constituted a greater proportion of the snail population, and *Pleurocera* was relatively less abundant. Proportionately, sandy substrates are less abundant between Dallas City and Keokuk than on Transect 3.

At Stations 4, 6, and 7 the snail population was about 350/m$^2$ in June, rose to around 900/m$^2$ by late summer, then fell to about 500/m$^2$ by December. At Stations 10 and 14 the population of about 200/m$^2$ was usually lower than at other stations, except when the population peaked at about 400/m$^2$ in August. At Station 8 the snail population fluctuated erratically, and snails disappeared in October, perhaps having been eaten by leeches which were abundant there in September. At Station 1 the snail population on the bottom increased from about 200/m$^2$ in August to about 2,000/m$^2$ in September, when aquatic plants began to disappear.

Gastropods are important food for diving ducks and a few species of fish. *Fontigens, Somatogyrus,* and *A. lustrica* were used most heavily (Thompson, 1973). *Somatogyrus,* because of its larger size, probably provides the most food.

Perhaps the most striking aspect of Pool 19's benthic community was the great preponderance of fingernail clams.

### *Pelecypoda*

Three species of *Pisidium* and four species of *Sphaerium* were identified as follows:

*Pisidium compressum, P. nitidum, P. variabile, Sphaerium lacustre, S. simile, S. striatinum, S. transversum*

*S. transversum* was especially abundant and seemed to be everywhere (except for areas of current-swept bare rock and sandy shores subject to wave action); in numbers, it dominated nearly every sample. In some parts of Pool 19 densities of *S. transversum* exceeded 100,000/m$^2$ (Fig. 4). These densities may be unparalleled in other bodies of water. For example, Pennak (1953) and Reid (1961) reported densities of sphaeriids in favorable habitats at 5,000/m$^2$ or more. In 1915 Richardson (1921) found about 4,000 *S. transversum* (as *Musculium*

Table 4. Total number and percentages of gastropods at nine stations during the summer of 1967 (four core samples collected monthly.

| | | Clayey silt | | | | Clayey sand | Clay-sand | | Sand | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Stations | | 1 | 9 | 10 | 14 | 7 | 4 | 8 | 5 | 6 | |
| Times sampled | | (7) | (4) | (7) | (7) | (7) | (7) | (7) | (5) | (7) | Total |
| *Physa* | | 2 | 2 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 8 |
| | (%) | 1 | 29 | - | 10 | - | 3 | - | - | - | 1 |
| *Amnicola* | | 45 | 0 | 0 | 10 | 3 | 10 | 0 | 3 | 10 | 81 |
| | (%) | 24 | - | - | 46 | 5 | 17 | - | 2 | 9 | 13 |
| *Somatogyrus* | | 0 | 0 | 2 | 8 | 10 | 6 | 7 | 16 | 21 | 70 |
| | (%) | - | - | 11 | 36 | 15 | 10 | 23 | 12 | 19 | 11 |
| *Fontigens* | | 3 | 2 | 5 | 2 | 33 | 27 | 9 | 85 | 14 | 180 |
| | (%) | 2 | 29 | 26 | 9 | 50 | 47 | 30 | 65 | 13 | 29 |
| *Campeloma* | | 0 | 2 | 6 | 0 | 4 | 2 | 7 | 5 | 1 | 27 |
| | (%) | - | 29 | 32 | - | 6 | 3 | 23 | 4 | 1 | 4 |
| *Lioplax* | | 0 | 1 | 5 | 0 | 9 | 4 | 4 | 2 | 11 | 36 |
| | (%) | - | 14 | 26 | - | 14 | 7 | 14 | 2 | 10 | 6 |
| *Viviparus* | | 3 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 6 |
| | (%) | 2 | - | - | - | 2 | 2 | 3 | - | - | 1 |
| *Valvata* | | 132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 132 |
| | (%) | 71 | - | - | - | - | - | - | - | - | 21 |
| *Pleurocera* | | 0 | 0 | 1 | 0 | 6 | 6 | 2 | 19 | 55 | 89 |
| | (%) | - | - | 5 | - | 9 | 10 | 7 | 15 | 49 | 14 |
| Total | | 185 | 7 | 19 | 22 | 66 | 58 | 30 | 130 | 112 | |

*transversum*)/m² in the Illinois River. In 1952 Paloumpis and Starrett (1960) found 24,000 sphaeriids/m² in Middle Quiver Lake on the Illinois River (the total included more than one species). Since 1969 I have collected sphaeriids in ponds, lakes, ditches, small streams and rivers in many states, but nowhere have I found sphaeriid populations that would come even close to rivaling those of Pool 19. *S. transversum*'s rapid growth and reproduction coupled with the ability of its young to survive for long periods deep in the substrate (where they may escape predation, parasitism, and unfavorable water conditions) may be important factors in its abundance (Gale, 1973).

*S. striatinum* was the second most abundant sphaeriid in Pool 19 and was also widely distributed. *S. transversum* made up over 99% of the sphaeriid population between June and December, but *S. striatinum* made up 4% of the total weight. *S. striatinum* was relatively more abundant in spring. Because of low densities, *S. lacustre* was not collected during systematic sampling but was found at Transect 3, Station 1, and nearby in Hoenigs's slough. A single empty shell of *S. simile* was found at Station 6. *Pisidium* spp. occurred at Stations 1 and 6 in low numbers.

*S. transversum* and to a much lesser extent *S. striatinum* are important food for hundreds of thousands of migrating diving ducks that stop on Pool 19 in fall and spring (Thompson, 1973; Thornburg, 1973). Thompson estimated that diving ducks consumed 2,085,000 kg of sphaeriids in fall of 1967. This represents about 24% of September's (1967) standing crop. It may well be the area's great abundance of sphaeriids that attracts diving ducks.

Large clams or mussels are still fairly abundant in Pool 19. Sandy areas seem to contain the most species, many of which are thick shelled. Some thin-shelled species, such as *Anodonta grandis,* and a few thick-shelled species, appear to thrive in mud. Mussels collected in Pool 19 by Ellis (van der Schalie and van der Schalie, 1950) in 1931 and by me from 1966-68 are listed in Table 5 along with those collected in the Illinois River in 1966 by Starrett (1971). There has been little, if any, qualitative change in the mussel fauna of Pool 19 between 1930-31 and 1966-68. Ellis found three species that I did not. Two, *F. ebenus* and *S. rugosus*, were scarce in 1930-31 and *L. complanata* only slightly more abundant. All three species may have been present in 1966-68 but were missed because of their scarcity.

In 1966-68 I collected five species not found by Ellis. Of these, *A. confragosus, P. lineolata,* and *T. truncata* were not abundant. *C. parva* was fairly common in backwaters where Ellis may have not sampled. Empty shells of *T. verrucosa* were found occasionally in 1966-68. Probably all five species were present in 1930-31, but were missed because of low densities.

The mussel fauna of the heavily polluted Illinois River appears similar to that of Pool 19. Starrett collected 21 of the 25 species found in Pool 19 (Table 5); only 2 species (*A. suborbiculata* and *L. radiata*) and 1 subspecies (*A. grandis grandis*) were found in the Illinois River but which were not collected in Pool 19. *A. plicata* was the most abundant clam (62.4%) collected by Starrett and by Ellis (*as A. peruviana*). *A. imbecillis* was by far the most common species in my study and most specimens were young (less than 3 cm long). These small specimens could be easily missed collecting with a crowfoot bar, mussel dredge, and by hand (as Starrett did), and different collecting techniques could account for much of the differences in relative abundance.

Since the 1870-1900 period, 25 species of mussels have been extirpated from the Illinois River and adjacent lakes (Starrett, 1971). If the mussel fauna of the Mississippi River during the late 1800's resembled that of the Illinois River as much as it does today, then many species of mussel have disappeared from Pool 19.

A quantitative survey of the mussels of the Upper Mississippi River is badly needed. Qualitative data will not suffice, if the mussels are to be managed; and management seems essential if they are to survive. Obtaining good population estimates with conventional sampling gear is difficult, however, because mussels are often widely spaced and the samples, therefore, are too small. The most reasonable answer to the sampling problem would seem to be the use of a SCUBA diver to collect clams inside measured areas.

Table 5. Number of mussels collected by Ellis in 1930-31 (van der Schalie and van der Schalie, 1950) and number collected in ponar grab sampling in 1966-68 in Pool 19, Mississippi River. An "X" indicates species collected with other gear but absent in ponar samples. A "P" denotes species collected alive in the Illinois River by Starrett (1971) in 1966; common names are from Starrett.

| | | Pool 19 | | Illinois |
|---|---|---|---|---|
| | | 1930-31 | 1966-68 | River |
| *Amblema (peruviana) plicata* | Three-Ridge | 87 | X | P |
| *Anodonta grandis corpulenta* | Floater | 22 | X | P |
| *A. grandis grandis* | Floater | 0 | 0 | P |
| *A. imbecillis* | Paper Pond Shell | 12 | 29 | P |
| *A. suborbiculata* | Heel-Splitter | 0 | 0 | P |
| *Arcidens confragosus* | Rock Pocketbook | 0 | X | P |
| *Carunculina parva* | Liliput Shell | 0 | X | P |
| *Fusconaia ebenus* | Ebony Shell | 1 | 0 | P |
| *F. flava* form *undata* | Pig-Toe | 24 | X | P |
| *Lampsilis anodontoides* | Slough Sand-Shell | 3 | X | P |
| *L. radiata* | Fat Mucket | 0 | 0 | P |
| *L. ventricosa* | Pocketbook | 14 | X | O |
| *Lasmigona complanata* | White Heel-Splitter | 6 | 0 | P |
| *Leptodea fragilis* | Fragile Paper Shell | 48 | 2 | P |
| *Ligumia recta* | Black Sand-Shell | 2 | X(dead) | O |
| *Megalonaias gigantea* | Washboard | 9 | 2 | P |
| *Obliquaria reflexa* | Three-Horned Warty-Back | 26 | 2 | P |
| *Obovaria olivaria* | Hickory Nut | 11 | 1 | P |
| *Plagiola lineolata* | Butterfly | 0 | X | O |
| *Potamilus (Proptera* or *Leptodea) laevissimus* | Fragile Heel-Splitter | 9 | X | P |
| *Potamilus alatus (Proptera alata)* | Pink Heel-Splitter | 10 | X | P |
| *Quadrula nodulata* | Warty-Back | 24 | X | P |
| *Q. pustulosa* | Pimple-Back | 20 | 3 | P |
| *Q. quadrula* | Maple-Leaf | 59 | 4 | P |
| *Strophitus rugosus* | Squaws Foot | 1 | 0 | O |
| *Tritogonia verrucosa* | Buckhorn | 0 | X(dead) | P |
| *Truncilla donaciformis* | Fawn's Foot | 23 | 9 | P |
| *L. truncata* | Deer Toe | 0 | X | P |
| Total species | | 20 | 22 | 24 |

## Effects of dredging

Of those who have investigated the fauna of Pool 19 in recent years (Jude, 1968; Gale, 1969; Ranthum, 1969; Thompson, 1973; Rogers, 1973; Thornburg, 1973) none has expressed serious opposition to the dredging of a service channel from the main river channel to shore. Because the size of the area to be dredged is small in proportion to the size of Pool 19, dredging effects will probably be negligible, and it will be difficult, if not impossible, to measure significant biotic changes except in the vicinity of dredging. However, dredging will contribute to an existing problem of excessive siltation downstream, and excavated substrates should be spoiled on adjacent land areas rather than being returned to the river. Increased industrial development resulting from the navigational channel probably poses more of a threat to the environment than the channel itself.

Thompson (1973) and Thornburg (1973) point out the great importance of Pool 19 to migrating diving ducks and Thornburg suggests that part of Pool 19 might be needed as a refuge, if waterfowl disturbance by man is increased. The idea of establishing a refuge there seems attractive but before it is considered seriously at least three important questions concerning fingernail clams should be answered. First, is Pool 19 unique in its great numbers of exploitable fingernail clams, or do they occur in abundance in adjacent pools? If they do, these pools might be used more by ducks, if the need arose. Second, what effect would greater numbers of diving ducks (or diving duck days) have upon fingernail clam populations, their main food source? The possibility exists that diving ducks might overexploit clams in open water as fish appear to have done in shallow areas, adjacent to vegetation. However, diving ducks are usually not present during the clam's growing season. Third, what is the life expectancy of Pool 19 as a major fingernail clam producer? Parts of Pool 19 that have silted in enough to permit the growth of submergent vegetation (i.e., coves and some areas near the dam) contain comparatively few clams. Without proper watershed management upstream, siltation will pose an increasingly greater threat to clam production.

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